Research Report 1992

Development of Two Courses-of-Fire: Night Fire with Aiming Lights and Combat Field Fire

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Consortium of Universities of Washington

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14. ABSTRACT
The report summarizes prior research on the development of two courses-of-fire, which are documented in the Army's Marksmanship Field Manual. One course is the Night Fire qualification or record fire course developed for using aiming lights/pointers/illuminators with night vision goggles. Research on the night fire course and standards was conducted from 1998-2000. The day qualification scenario was found to be too challenging at night because of the inability of Soldiers to detect far targets with goggles under reduced illumination conditions. For night qualification changes were then made to the day scenario that reduced the number of longer-distance targets, including removal of all 300m target presentations. The other course-of-fire is Combat Field Fire, developed in 2009 and investigated again in 2010. The report documents both research efforts and presents the core information on Soldier performance and required skills. The report fills a gap in the marksmanship training and doctrine literature by summarizing how both courses and standards were developed.

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The author acknowledges the primary role that SSG Shoemaker from 2/29, 197th Infantry Brigade at Ft. Benning, GA had in taking the initiative to develop a revised night fire scenario and examine it with Infantry One-Station-Unit-Training Soldiers. All the Soldiers and leaders involved at Ft. Benning, GA in the 192th and 198th Infantry Training Brigades are also acknowledged, as their support was critical in obtaining the performance data on Combat Field Fire. These leaders were also responsible for ensuring this course-of-fire was included in the marksmanship Field Manual.

DEVELOPMENT OF TWO COURSES-OF-FIRE:
NIGHT FIRE WITH AIMING LIGHTS AND COMBAT FIELD FIRE

EXECUTIVE SUMMARY

Research Requirement:

Army rifle courses-of-fire and standards evolve over time as evidenced in the changes in the Army's marksmanship Field Manuals (FMs). However, typically, the reasons for those changes are not documented in the FM, and therefore provide little guidance to doctrine writers who must periodically update the FM. This report describes the development of the current night fire course and scorecard for aiming lights and night vision goggles, and summarizes the research behind Combat Field Fire (CFF). It presents the rationale and research behind these two marksmanship courses and standards which are in the Army's training and doctrine literature. The research supported the U. S. Army Infantry School in the development of standards for both courses-of-fire.

Procedure:

For the night fire course, research conducted by the Army Research Institute for the Behavioral and Social Sciences (ARI) was re-examined. Most of this research had not been published in ARI reports. Four research efforts were executed from 1998 to 2000, in support of the Infantry School and the Training and Doctrine Command (TRADOC) Systems Manager-Soldier. The first two efforts used the day qualification scenario for night fire; the other two efforts used a revised night fire qualification scenario. Criterion measures were the percentage of Soldiers who qualified and the probability of hitting targets at different distances. For CFF, two research efforts which had been documented in ARI reports were re-examined. Soldier performance as a function of the target arrays as well as percentages of Soldiers in the different marksmanship categories were the major criteria. The primary results from both efforts were summarized and consolidated to provide a succinct picture of the research findings on CFF.

Findings:

During night fire, extraneous factors, such as the amount of night-time illumination and target contrast on the firing range, negatively impacted Soldier performance. The revised night fire scenario was shown to yield a higher percentage of qualified Soldiers. Changing the day qualification scenario so there were fewer long-distance targets and more close-in targets meant that proportionately more targets could be detected and therefore engaged. When both research efforts on CFF were integrated, the results validated the cut-points established in the initial CFF research as well as the necessity for proper training to enable Soldiers to perform well on this complex course-of-fire.

Utilization and Dissemination of Findings

The report provides a single reference for doctrine writers on two Army courses-of-fire which are in the marksmanship FM. The findings document the rationale for the two courses-of-fire plus the methods used to determine standards for each course. The research methods and all firing results are available for use if future changes are desired. The findings were disseminated to the Training and Doctrine Division of the US Army Infantry School which is responsible for updating the Army's marksmanship FM, and to the Infantry Brigades which supported both efforts: the 192nd, the 197th and 198nd Infantry Brigades. The CFF results were briefed to the Commanding General, U.S. Army Infantry School.

DEVELOPMENT OF TWO COURSES-OF-FIRE:
NIGHT FIRE WITH AIMING LIGHTS AND COMBAT FIELD FIRE

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Development of Two Courses-of-Fire: Night Fire with Aiming Lights and Combat Field Fire

Army rifle courses of fire and standards have evolved over time as evidenced in the changes in the marksmanship Field Manuals (FMs) from 1940 to 2010 (Dyer et al., 2010). However, typically, the reasons for those changes were not documented in the FMs. The purpose of this report is to document how the current night fire scorecard (FM 3-22.9, Department of the Army [DA], 2008, 2011, Change 1, Record Night Fire Scorecard DA Form 7489) was developed and to summarize the research behind Combat Field Fire (CFF) standards (FM 3-22.9, DA 2011, Change 1, Combat Field Fire Scorecard DA Form 7682). The rationale for the night fire course-of-fire and standards for aiming lights, which are used with night vision goggles (NVGs), has not been formally documented in a research report available to the Army community. CFF has been documented in several reports and is summarized here. The Army Research Institute (ARI) for the Behavioral and Social Sciences at Ft. Benning supported the U.S. Army Infantry School in the development of standards for both courses-of-fire as well as the Training and Doctrine Command (TRADOC) Systems Manager-Soldier in the work on night fire.

Night Fire Standards for Aiming Lights and Night Vision Goggles

Background

The current standards for aiming lights (ALs), also called illuminators or pointers, developed from work with rifle platoons at Ft. Bragg, NC and with Infantry One-Station-Unit-Training (OSUT) Soldiers at Ft. Benning, GA. The phrase "aiming light' is used throughout the report as that was the common terminology when the research was conducted. The revised standards and scenario were refined by personnel from 2/29 Infantry, 197th Infantry Brigade in 1998-1999. ARI supported this effort with training observations, data collection, and analysis. The qualification problem with ALs and NVGs first emerged when 2/29 Infantry instructors were responsible for training a rifle platoon at Ft. Bragg, NC on government furnished equipment (GFE) prior to a Land Warrior (LW) test. The guidance from the Commanding General of the Infantry School was to shoot as well at night as during the day. At this time, there was very limited distribution of and experience with ALs and NVGs in the Army. Shooting results showed that achieving the day time qualification standards at night with ALs and NVGs was not possible, due primarily to the inability to detect targets with NVGs, but the day standards could be met with the thermal weapon sight (TWS) at night. A revised scenario and standards for ALs and NVGs emerged through the efforts of 2/29 Infantry, and is in the current marksmanship FM (FM 3-22.9, DA 2008, 2011, Change 1, DA Form 7489). It is also cited in FM 3-22.9 (DA, 2006, Change 4) but not presented.

This document presents firing data on the findings which were documented in previous ARI reports (one published and three unpublished) and a briefing to the Commander of the 2/29 Infantry (Dyer, 1999a). The results are presented in the following chronological order:

Rifle Platoon, Ft. Bragg, Data collected in 1998 (called the baseline platoon in this report)

Rifle Platoon, Ft. Bragg, Data collected in 1998 (called the LW platoon in this report)

Infantry One Station Unit Training (OSUT), Ft. Benning, Data collected in 1999
Rifle Platoon, Ft. Bragg, Data collected in 2000 prior rotation to the Joint Readiness Training Center (JRTC) (called the LW platoon-JRTC)

Original Course-of-Fire

Test concept

The Land Warrior (LW) system was scheduled for testing in 1999 with a rifle platoon from Ft. Bragg, NC. The test concept involved a comparison with a baseline platoon also from Ft. Bragg. Since the LW Soldiers were to have new Government furnished equipment (GFE) -- optics and sights, the concept was to also train the baseline platoon on the same GFE (specifically, the M68 close combat optic (CCO), the TWS, and the PAQ-4C and PEQ-2A ALs which were used with NVGs). Some platoon members had previously used NVGs and a form of AL. None had used the CCO or the TWS prior to the training. In 1998, GFE training for both the baseline platoon and the LW platoon was conducted by instructors from 2/29 Infantry from Ft. Benning, GA. Training of the baseline platoon occurred prior to training of the LW platoon. For both these efforts, the guidance from the Commanding General Ft. Benning regarding the night optics/devices was to shoot as well at night as during the day. The ARI at Ft. Benning supported the TSM-Soldier (TRADOC Systems Manager-Soldier) in training observations, data collection and data analysis. The LW system test was postponed until 2000.

Baseline platoon results (1998)

The training for the baseline platoon occurred from 30 March 1998 through 9 April 1998. The qualification scenario operative in 1998 had only two positions: foxhole supported and prone unsupported with 20 targets per position for a total of 40 targets (FM 23-9, DA 1989, reproduced in Table A1 in Appendix A). Standards for marksmanship categories were the same as the current standards: Expert - 36 to 40 hits, Sharpshooter - 30 to 35 hits, and Marksman - 23 to 29 hits). Practice qualification and final qualification were executed for the CCO, ALs (PAQ-4C and PEQ-2A), and TWS. Soldiers who did not qualify on the first attempt at qualification were given additional attempts to qualify.

General findings, as stated in a Training Effectiveness Analysis (TEA) (Dyer, Reeves & Wampler, 1998; Dyer, 1999b), were that all Soldiers qualified with the CCO (day) and the TWS (night) on the M4 carbine, but only 71% qualified with the AL (night) with the ammunition available to the platoon (see Tables 1 and 2). The major conclusions were that the qualification scenario and standards for ALs needed to be examined with regard to the capability of the technologies used (i.e., ALs with unity-power NVGs), and that the day qualification standards could be achieved with the TWS.

With regard to the ALs and NVGs, Soldiers could only engage and hit what they could see, and the capability of the NVGs to provide a good image seemed to be a limiting factor. The image quality, particularly of targets at 200 m and beyond, depended on the amount of night illumination and the configuration of the range (e.g., trees behind the farthest targets). Soldiers

used the PVS-7Bs NVGs. All ammunition allocated to the baseline platoon was consumed in the effort to qualify the Soldiers on the ALs.

All Soldiers fired in body armor. Thermal blankets were used on the targets for the TWS firing. Soldiers zeroed the CCO and the TWS prior to qualification. They boresighted the AL.

Table 1
Qualification Results for the CCO, AL, and TWS: Baseline Platoon Scheduled for LW Test (N = 24 Soldiers)

Qualification by Sighting System	Mean Score	Minimum Score	Maximum Score	Standard Deviation
CCO – day fire				
Practice Qualification	29.04	21	35	4.17
First attempt at Qualification	32.00	23	39	4.88
Final Qualification	33.71	28	39	3.44
TWS – night fire				
Practice Qualification	29.50	18	39	5.94
First attempt at Qualification	29.79	14	38	5.94
Final Qualification	30.79	23	38	4.01
ALs (PAQ-4C & PEQ-2A) – nightfire				
Practice Qualification	18.04	3	32	7.42
First attempt at Qualification	17.50	4	31	8.09
Final Qualification	23.62	15	31	4.92

Table 2 presents additional information on the gradual progress of Soldiers who qualified with repeated attempts on each of these optics/devices. Obviously, there was a substantial difference on the first attempt to qualify, with the AL qualifying percentage being very low. This percentage increased on the second attempt to qualify, but was still lower than the corresponding percentages for the CCO and TWS. The other major finding shown is the similar profiles in percentages of Soldiers who qualified with the TWS and the CCO.

Table 2
Cumulative Percentage of Soldiers Qualifying on CCO, AL, and TWS: Baseline Platoon Scheduled for LW Test

Sighting System	Cumulative Percentage of Soldiers			Comments
	Qualified in 1 Attempt	Qualified in 2 Attempts	Final Qualification (repeated attempts)	
CCO – day fire	79%	88%	100%	3 Soldiers qualified with 3, 4, & 8 attempts
TWS – night fire	88%	96%	100%	1 Soldier qualified with 4 attempts
ALs - night fire	29%	46%	71%	7 Soldiers not qualified after 1 to 5 attempts

Additional information from the Dyer, Reeves and Wampler (1998) report reproduced below cites the perceived reasons for the difficulties with ALs and NVGs. Figure 1 shows the differences in probability of hit at each target distance as a function of the amount of ambient illumination.

> "Several reasons are given for the difficulty in qualifying with the aiming lights and NVGs.
> - The range was surrounded by trees, making it extremely difficult to see the targets at 200 meters and beyond. There was no target contrast. At these far ranges, a dark target "popped up" against a dark background. If the background had been a sandy berm, then there would have been sufficient contrast to see a dark target.
> - The amount of ambient light varied over the four nights of firing. The impact of the amount of illumination is illustrated in Figure 2 [i.e., Figure 1 below]. On those nights with good illumination, Soldiers performed better.
> - At far distances, it is difficult to obtain a precise point of aim as the bloom from the aiming lights covers the target.
> - No guidance was provided on adjusting goggles to get a good focus and good visual acuity.
> - Some NVGs had defects and were in need of maintenance." (p. 25)

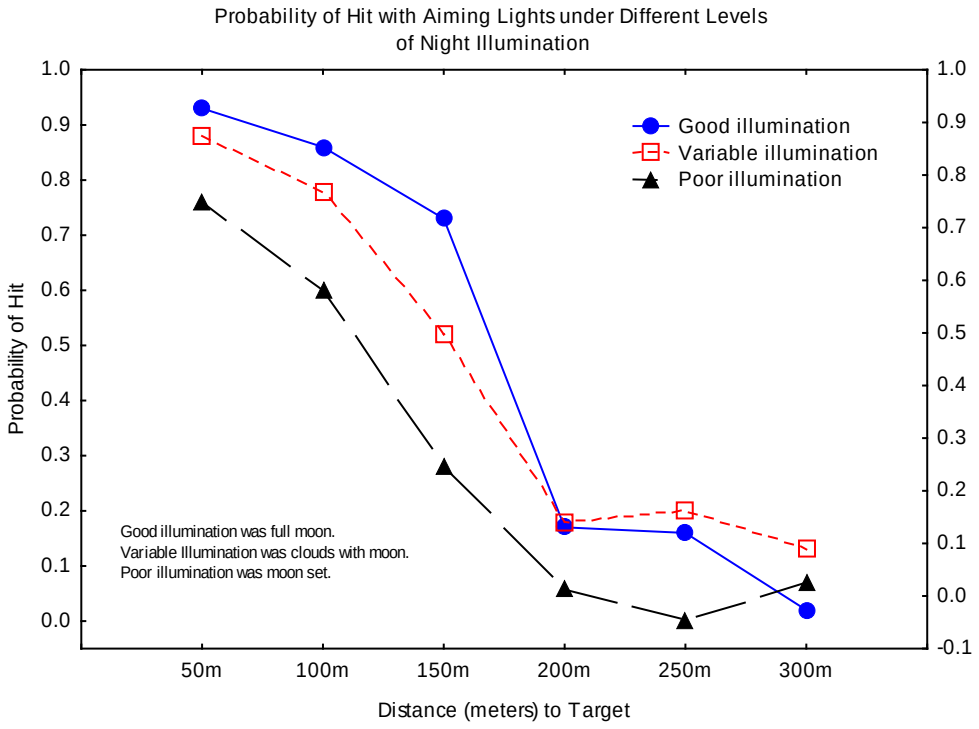

Figure 1. Effect of ambient illumination on probability of hit using the PAQ-4C and PEQ-2A ALs with NVGs when firing the 1989 day qualification course-of-fire (Baseline platoon). [Figure 1 in the Dyer, Reeves. & Wampler, 1989 report.]

Figure 2 below shows the probability of hit (ph) for each sight/device as a function of distance to the target for the first iteration of qualification (not the final qualification scores). The curves for the CCO and TWS were very similar, gradually declining with increased distance to the target. However, for ALs, the ph was much lower, declined initially at 150 m, and then dropped to a ph of about .10, and less at 200, 250 and 300 m.

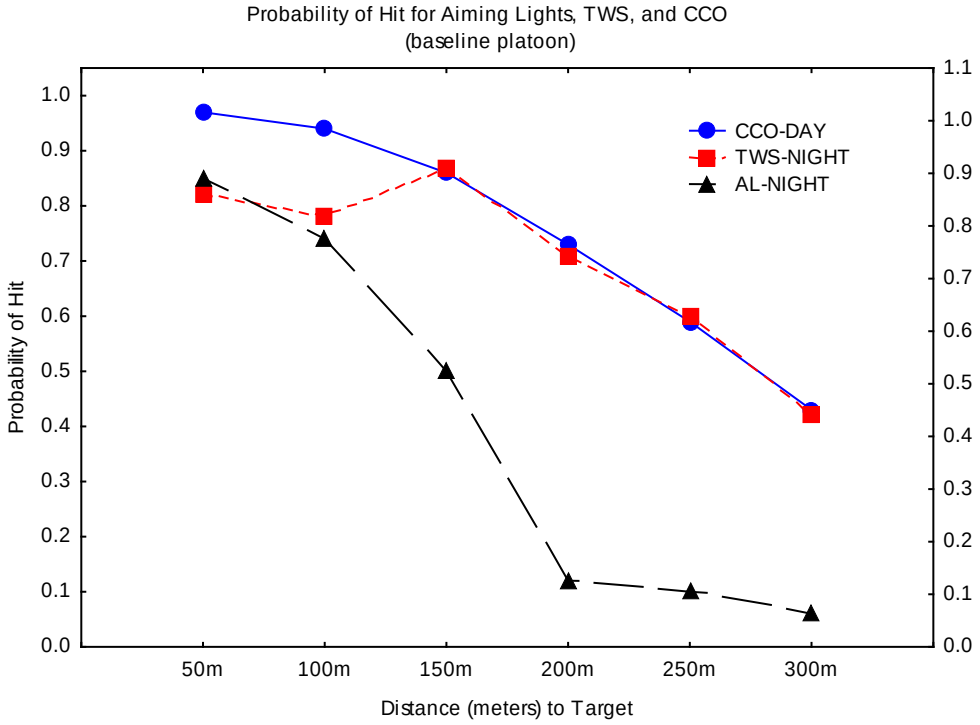

Figure 2. Hit performance on qualification by distance to target with the CCO, TWS, and AL (Baseline platoon).

LW platoon results (1998)

From the baseline platoon results, it was clear that the Commanding General's guidance to shoot as well at night as during the day was met with the TWS, but not with the AL-NVG combination. In December 1998, the opportunity to qualify with the same equipment presented itself again with the LW platoon (N = 19 Soldiers). The 2/29 Infantry instructors trained the LW platoon on the same equipment, except the LW platoon used the PVS-14 NVGs. These results are presented next. ARI researchers served the same role as training observers, data collectors, and data analysts. Zeroing/boresighting procedures were the same as with the baseline platoon. Thermal blankets were on the targets for TWS firing.

Qualification results for the LW Platoon are shown below in Table 3 (Dyer, 1999b, 1999c). Results were very similar to those with the Baseline platoon. Again, Soldiers were

given repeated attempts to qualify after their second attempt. In contrast with the baseline platoon, the LW platoon did not fire in body armor.

Table 3
Qualification Results for the CCO, AL, and TWS: LW Platoon Scheduled for LW Test (19 Soldiers)

Qualification by Sighting System	Mean	Minimum Score	Maximum Score	Standard Deviation
CCO – day fire				
Practice Qualification	26.87	13	38	6.85
First Attempt at Qualification	29.79	20	38	4.90
Final Qualification	31.26	26	38	3.48
TWS – night fire				
Practice Qualification [a]	---	---	---	---
First Attempt at Qualification	29.68	11	38	4.86
Final Qualification	29.89	11	38	4.59
ALs (PAQ-4C and PEQ 2A) – night fire				
Practice Qualification	14.17	6	25	6.03
First Attempt at Qualification	17.67	7	28	6.53
Final Qualification	25.22	15	35	4.49

[a] Insufficient time for practice qualification.

Table 4 presents additional information on the gradual progress of Soldiers who qualified after repeated attempts on each of these optics/devices. The results were very similar to what occurred with the baseline platoon. A high percentage of Soldiers qualified with the TWS and the CCO. Again, a lower percentage of Soldiers qualified with the AL on the first attempt, although the percentage increased somewhat on the second attempt to qualify. The difficulty of qualifying with ALs was illustrated by the repeated attempts by some Soldiers to qualify.

Poor performance with ALs was again attributed to target detection problems (see results by target distance in Figure 3). "Targets at the far distances were often difficult to find. On some lanes and under certain ambient light conditions, these targets were impossible to detect" (Dyer, 1999c, p. 34). The firing range used by the LW platoon was the same as that used by the baseline platoon so night lighting conditions and target contrast problems were very similar.

Table 4

Cumulative Percentage of Soldiers Qualifying on CCO, AL, and TWS: LW Platoon Scheduled for LW Test

Sighting System	Cumulative Percentage of Soldiers			Comments
	Qualified in 1 Attempt	Qualified in 2 Attempts	Final Qualification (Repeated Attempts)	
CCO – day fire	74%	84%	95%	2 Soldiers qualified with 3 and 5 attempts. 1 Soldier unqualified with 8 attempts
TWS- night fire	89%	95%	95%	1 Soldier unqualified with 4 attempts
ALs– night fire	28%	56%	89%	5 Soldiers qualified after 3 to 5 attempts. 2 Soldiers unqualified after 8 and 9 attempts.

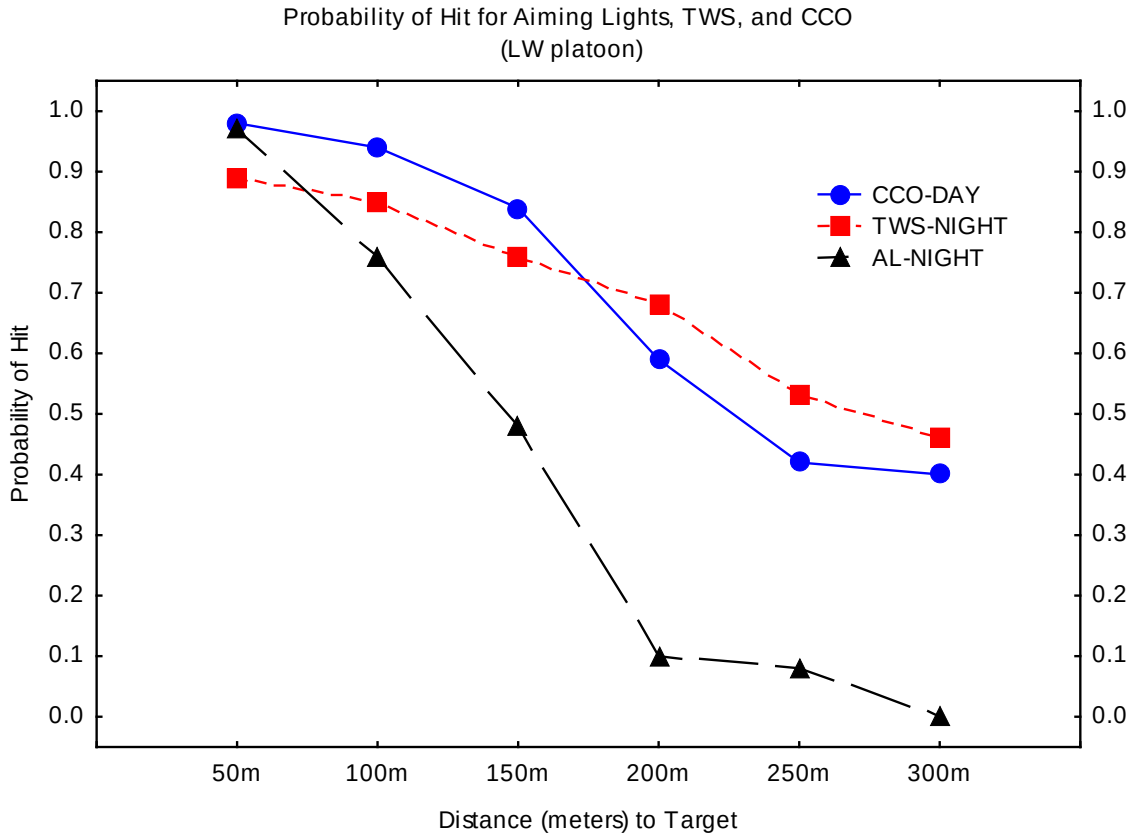

Figure 3. Hit performance on qualification by distance to target with the CCO, TWS, and AL (LW platoon).

LW Platoon summary

The firing results from Ft. Bragg showed the difficulties of hitting 200 m to 300 m targets with AL/NVGs. These problems were typically caused by factors beyond the firer's control. The primary limitation was the ability to see/detect targets with NVGs, because of the low level of illumination, and limited target contrast on many ranges due to a woodline at the back of the range. Ground fog was also found to degrade the NVG image. In addition, the AL became more diffused as the distance to the target increased, making it hard to obtain a precise aimpoint on the target. The ph at 200 m and beyond was less than .10, even under good illumination. These results occurred during qualification despite practice with AL/NVGs during field fire scenarios.

The results supported the concept of redistributing the number of targets at the different distances on the qualification course, so the 200 m to 300 m targets were not as critical in qualifying. The results also showed the importance of adjusting NVGs for best visual acuity as they impacted performance. Using the Ft. Bragg data, personnel from the 2/29 Infantry then examined ways of changing the night fire scenario and tested the revised scenario to develop standards. A major conclusion was that night fire standards must consider the total weapon system (both ALs and NVGs), and the capabilities/limitations of these system technologies.

Revised Course-of-Fire

Infantry OSUT results (1999)

After training the platoons at Ft. Bragg, the noncommissioned officer in charge (NCOIC) from 2/29 Infantry worked on establishing a revised scenario and qualification standards for AL/NVG. In 1999, this revised scenario was fired by Infantry OSUT Soldiers from four companies at Ft. Benning, GA. The Soldiers used the PVS-7D (helmet mounted) NVGs in conjunction with the PAQ-4C AL. They did not fire in body armor. The decision was made to change the number of targets at each distance, including removing all the 300 m targets, and to lower the cut-points for the marksmanship categories, with the unqualified cut-point being 16 hits and below.

Table 5 compares the total number of targets at each distance with the day scenario (which was in the FM 23-9, DA, 1989) to both the revised AL scenario in 1999 developed by 2/29 Infantry, and the current AL night fire scenario in the FM 3-22.9 (DA, 2008, 2011, Change 1). Results were briefed to the Commander 2/29 Infantry in 1999 (Dyer, 1999a). The last column in Table 5 shows the relative shift in number of targets from the 250 m to 300 m range band to the 50 m to 150 m range band.

Table 5

Comparison of Target Distributions in Day Qualification Scenario and Aiming Light Night Scenario (1999 and 2011)

Distance to Target	# of Targets			Relative Change in % Targets: From Day Scenario to DA Form 7489
	Day Scenario in FM (1989)	Revised AL Scenario (1999)	DA Form 7489 (current FM 2011)	
50 m	5	8	8	+7.5%
100 m	9	11	10	+2.5%
150 m	10	11	12	+5.0%
200 m	8	8	8	0%
250 m	5	2	2	-7.5%
300 m	3	0	0	-8.0%

Note. There is slight discrepancy in the number of targets at 100m and 150m between the AL scenario developed by 2/29 Infantry in 1999 and the number of target in the current marksmanship FM.

Soldiers in four Infantry OSUT companies fired the revised scenario once (equivalent to a practice record fire or practice qualification), but only one company (Company A with 192 Soldiers) had time for Soldiers to refire (equivalent to record fire). Also for this company, time restrictions meant that only the Soldiers who did not qualify the first time were allowed to refire. Consequently, only Soldiers in Company A fired under conditions which approximated the conditions for the rifle platoons at Ft. Bragg, and only their results are presented in this report.

For Company A, 75 of the 192 Soldiers (39%) qualified on the first or practice firing. Of the 117 Soldiers who refired, 61 qualified. Thus of the 192 Soldiers, 136 (71%) qualified. The mean score for the OSUT Soldiers on practice qualification was 13.8. The mean score for those who refired (did not qualify on practice qualification) was 16.3. Ambient conditions were poor for NVGs, i.e., no moon or stars.

Figure 4 shows the probability of hit data for OSUT Company A with ALs on the revised scenario. All Soldiers fired practice qualification. The only Soldiers who refired were those who did not qualify on practice qualification.

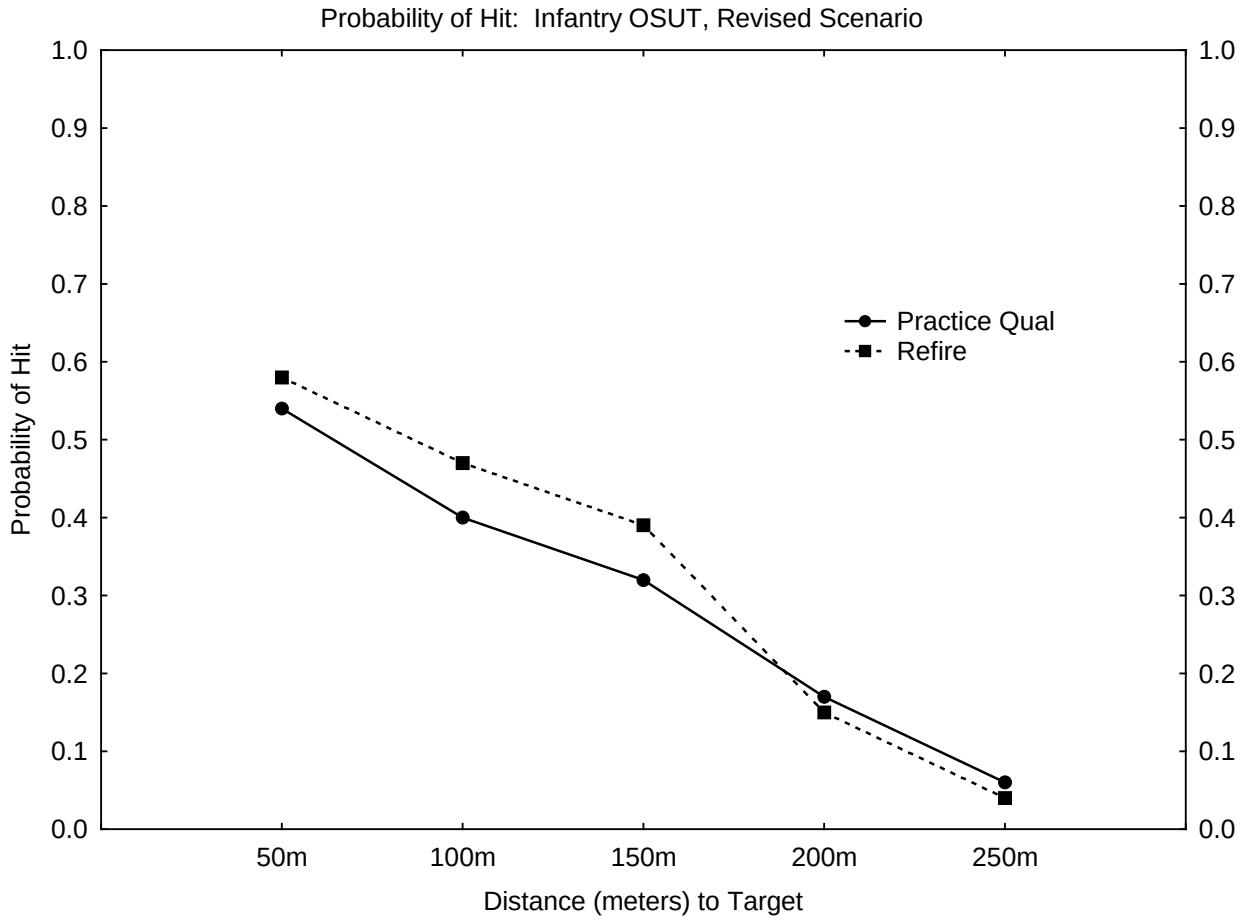

Figure 4. Hit performance with ALs by target distance for the OSUT Company (Company A) on the revised night scenario. [The practice qualification percentages represent all Soldiers on practice qualification (PQ) and the refire percentages represent the Soldiers who did not qualify on PQ].

Comparisons with the Ft. Bragg rifle platoon results were made with OSUT Company A as the firing conditions for this company (practice plus record fire for those who did not qualify) most closely approached the rifle platoon shooting conditions. The revised marksmanship categories that were developed are shown in Table 6 below, as well as the OSUT Company A results and estimated Ft. Bragg rifle platoon results based on the first attempt at Record Fire.

To determine whether the new scenario and revised cut-points would produce the same results with the Ft. Bragg platoons as with the OSUT Company, the previous 1998 probability of hit data from the rifle platoons were applied to the new scenario. Estimated scores for the rifle platoons on the revised scenario were calculated by multiplying the probability of hit values each Soldier achieved at each distance by the revised number of target exposures at each distance, and then summing across the target distances (from 50 m to 250 m) to get total number of hits. The frequency distribution of scores was determined and the percentage of Soldiers in each

marksmanship category, based on the revised cut-points, was calculated. The estimated results for the two rifle platoons as well as the actual results from the OSUT company (Company A) are in Table 6.

Table 6
Percentage of Soldiers by Marksmanship Category in Revised Aiming Light Night Scenario

Revised scenario -Marksmanship Categories	Marksmanship Category Cut-points	OSUT Soldier % (Company A)	Rifle Platoon % Estimates
Unqualified	16 hits & below	29%	29%
Marksman	17-23 hits	49%	24%
Sharpshooter	24-34 hits	22%	48%
Expert	35-40 hits	0%	0%

The OSUT results were 71% qualified (based on practice qualification and one record fire). The estimated percentage of rifle platoon Soldiers who would have qualified on the revised scenario was also 71%. The major difference in the results was that the estimated Sharpshooter percentages were higher for the rifle platoons and the estimated Marksman percentages were lower for the rifle platoons, the more experienced Soldier population at Ft. Bragg.

LW Platoon-JRTC Results (2000)

In 2000, a reconfigured LW system was given to another rifle platoon from Ft. Bragg. This platoon was trained on the actual LW equipment prior to a rotation to JRTC. Again, the 2/29 Infantry instructors trained the platoon members on the same GFE equipment cited previously. ARI served the same role as before (Dyer et al., 2000). During this training, the revised AL/NVG scenario was used. Soldiers who did not qualify on first attempt were allowed to refire. Zeroing/boresighting procedures were the same as with the prior platoons at Ft. Bragg. Thermal blankets were used on the targets during TWS firing.

Tables 7 and 8 show the results for this platoon. Due to an extended check fire the night when the TWS was fired and in order to save time, no practice qualification was conducted with the TWS. The course-of-fire for the CCO and TWS remained the day qualification course. Only the AL course-of-fire changed.

Despite the change in the AL scenario, the AL qualification percentages were still lower than the CCO and TWS percentages. The 74% qualification percentage after two attempts was similar to the results from OSUT (after two attempts), and higher than what was achieved by rifle platoons with the original scenario (46% and 56%, see Tables 2 and 4). When practice qualification scores were extremely low with the AL (i.e., less than 5 hits), the Soldiers were taken off the firing line and reboresighted. In most cases, the Soldiers then qualified.

Table 7

Qualification Results for the CCO, AL, and TWS: LW Platoon – JRTC Rotation in 2000 (~30 Soldiers)

Qualification by Sighting System	Mean Score	Minimum Score	Maximum Score	Standard Deviation
CCO (*n* = 32) - day fire; day qualification scenario				
Practice Qualification	28.37	14	39	5.92
First Attempt at Qualification	31.91	21	39	4.93
Final Qualification	32.97	27	39	3.51
TWS **(***n* = 29) – night fire; day qualification scenario				
Practice Qualification	25.11	5	40	7.15
First Attempt at Qualification	23.70	13	30	5.62
Final Qualification	28.22	18	40	4.10
ALs (PAQ-4C and PEQ-2A**)** (*n* = 31) – night fire; revised night fire scenario				
Practice Qualification	11.10	0	29	7.91
First Attempt at Qualification	14.63	0	28	8.05
Final Qualification	21.83	12	33	5.29

Table 8

Cumulative Percentage of Soldiers Qualifying on CCO, AL, and TWS: LW Platoon- JRTC Rotation in 2000

Sighting System	Cumulative Percentage of Soldiers			Comments
	Qualified in 1 Attempt	Qualified in 2 Attempts	Final Qualification (Repeated Attempts)	
CCO	84%	91%	100%	
TWS	79%	90%	90%	2 Soldiers unqualified
ALs (PAQ/PEQ & NVGs)	48%	74%	81%	5 Soldiers un qualified

Note. CCO was day fire with day qualification scenario; TWS was night fire with day qualification scenario; ALs was night fire with revised night fire qualification scenario.

Figure 5 presents the probability of hit with each sight/device as a function of distance to the target. The AL line indicates a relatively sharp drop in ph after 150 m, typical of previous results obtained on the same range at Ft. Bragg. Notice that the CCO and TWS curves are very similar from 50 m to 300 m, with the TWS curve being about 10 to 15 percentage points lower.

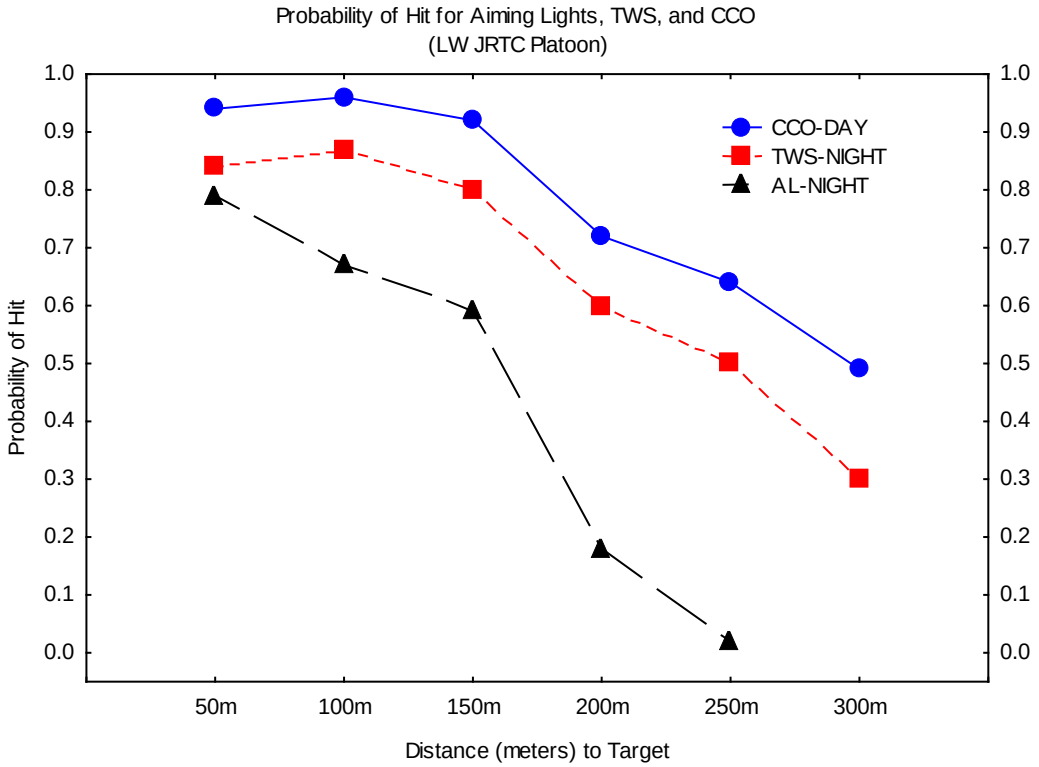

Figure 5. Hit performance by target distance with the CCO, TWS, and AL (LW platoon – JRTC). (CCO - day fire with day qualification scenario; TWS - night fire with day qualification scenario; ALs -night fire with revised night fire qualification scenario).

Night Fire Discussion and Conclusions

Figure 6 shows the ph curves for ALs from the four major research efforts documented in this report. The rifle platoon data were similar, with OSUT performance lower from 50 m to 150 m. The revised scenario did not change the difficulty of hitting at the different target distances, as no firing condition changed that would positively impact the likelihood of hitting targets per se. However, Table 9 shows that the qualification percentages did increase with the revised scenario, particularly on the second attempt, as the scenario had fewer targets at the longer distances and more targets at the closer distances. In sum, the revised scenario had the intended effect.

However, the results again show that the ph dropped substantially after 150 m. Perhaps the qualification scenario should have eliminated any targets beyond 150 m.

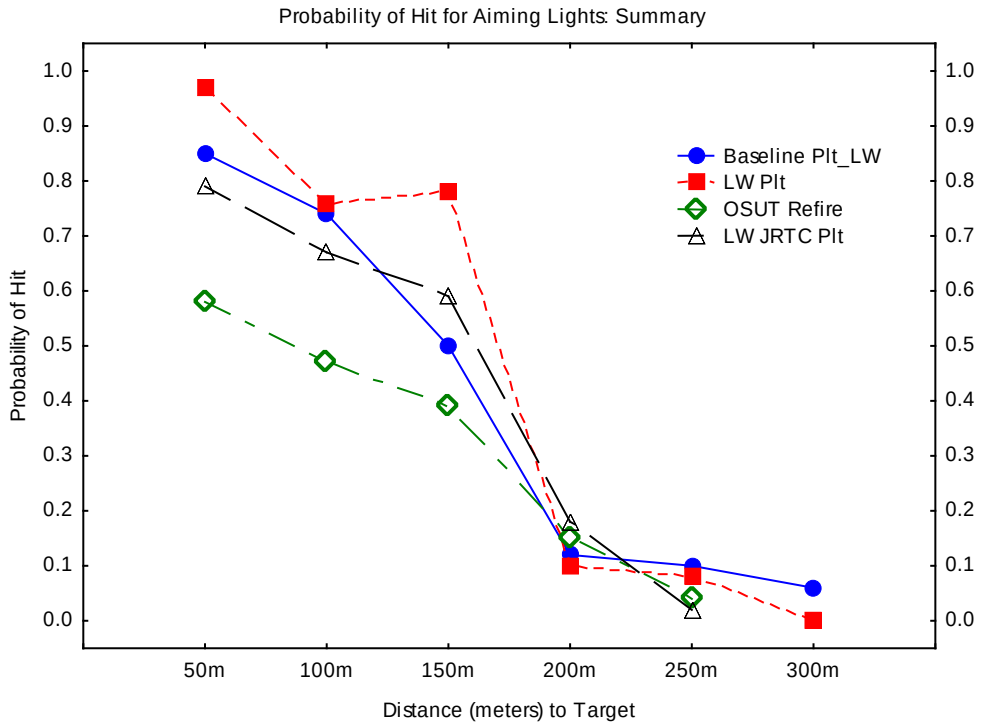

Figure 6. Probability of hit for ALs from each of the four research efforts.

Table 9
Summary of Aiming Light Qualification Results: Percent Soldiers Qualified

	% Soldiers			
	Original Scenario		Revised Scenario	
Qualification Attempt	Baseline platoon (n = 24)	LW platoon (n=19)	OSUT company (n = 192)	LW platoon JRTC (n = 31)
1st Attempt	29%	28%	39%	48%
2nd Attempt	46%	56%	71%	74%
Multiple Attempts	71%	89%	Not done	81%

Although the previous reports highlighted the problems with engaging targets with ALs because of the amount of ambient illumination and the target contrast resulting from the nature of the terrain, other factors also impacted the ability to engage targets. If the range lights are on, the extreme contrast between the light from these lights and an unlit, dark range make it very difficult to detect targets. If there are "city" lights in the background, this also affects the ability of the firer to see the targets. Another lesson learned was that NVGs need to be adjusted for the clearest image to increase the likelihood of detecting targets and achieving a better point of aim. Firing accuracy was also found to be dependent on the quality of the boresight that was achieved.

After these data were obtained, NVG and AL technologies have improved. In 2015, some additional night fire data (revised scenario, DA Form 7489) were obtained from 24 non-commissioned officers attending the Master Marksman Trainer Course conducted by the United States Army Marksmanship Unit (USAMU) at Ft. Benning., GA (Dyer, 2015b). The firers had received two weeks of training, primarily day firing, prior to the night event. For the night fire, the AN/PEQ-15 AL/illuminator and the AN/PVS-14 NVGs were used. Firers executed the night scenario once for practice and once as a final effort. Firing conditions were "optimum" in that the ambient illumination was excellent, the terrain was flat, and the farthest targets could be seen against a sandy background. ARI researchers did not observe this firing. Night performance was extremely high with means of 30 hits and 32 hits for practice record fire and record fire, respectively, out of 40 targets. USAMU instructors indicated that they had typically not observed such a high performance level in prior classes.

These data show that under some conditions, noncommissioned officers can perform well at night with ALs and NVGs. These results may not generalize to other Soldiers with less marksmanship experience and/or who shoot under less than optimum lighting and range conditions. More extensive research is needed to determine whether the latest illuminator and goggle technologies substantially change Soldier performance with night fire.

TWS Qualification Considerations

All the rifle platoon firing at night also involved the TWS. These data clearly showed night results very similar to that achieved with the CCO during the day. Thermal blankets were used for zeroing and for the qualification course. Because of the magnification on the TWS, trainers learned that Soldiers must be reminded to scan their sector of fire. Another lesson learned is that a Soldier can zero at night or during the day, although day zeroing is faster. Clearly, Soldiers qualified with the TWS with the day qualification scenario (1998 version).

In a later effort with the TWS and CCO (Dyer et al., 2005), the TWS results at night, from 75 m to 300 m, were again very similar to CCO results during the day (prone supported position). The data from the three scenarios used in this effort are summarized in Table B7, Appendix B. Although there is a need to test TWS performance using the current, three-position, qualification scenario to verify the standards, there appears to be no reason to expect performance to decline. Thus, the night fire scorecard in the marksmanship FM should clarify that it refers to using ALs/illuminators/pointers with NVGs, and not to thermal sights.

Combat Field Fire (CFF)

Purpose of CFF

Army Soldiers train to achieve the skills required in what is known as record fire or qualification. The qualification course itself has changed several times since the 1940s (Dyer et al., 2010). Although the reasons for changes are typically not cited in the marksmanship FMs, in some cases the reasons are fairly evident. For example, there was a switch from known distance (KD) type targets to pop-up, timed targets when the later technology was developed. Weapon system capabilities also impacted qualification (Ehrhart, 2009).

The CFF course-of-fire was developed in 2008-2009 by Infantry leaders as a marksmanship scenario that stressed skills needed in Operation Iraqi Freedom (OIF). At that time, graduates from Infantry OSUT and Basic Combat Training were often deployed relatively quickly after being assigned to their first unit. Thus the intent was not to replace the current qualification course-of-fire but to supplement it with additional skill requirements which more closely approximated a combat setting (e.g., use of barricades, firing at a target more than once, tactical magazine changes). Basic marksmanship skills were perceived as a prerequisite to firing CFF. CFF was tested and standards were developed in 2009 by the Army Research Institute per request of the Commanders of the 198th, 192nd and 197th Infantry Brigades at Ft. Benning. It was approved by the Commanding General, Infantry School, and included in the marksmanship FM (FM 3-22.9, DA, 2011; Change 1) as an advanced rifle marksmanship course of fire.

The purpose of this section of the report is to describe CFF, the skills required, and how the standards were developed. The findings are based on two technical reports (Dyer et al., 2010, 2012). The 2010 report documented Soldier performance obtained in January through April 2009, and how the standards were developed. The 2012 report provided another validation of the standards which was conducted in 2010.

The CFF Scenario

The CFF scenario is shown graphically in Figure 7. Table 10 is a tabular presentation of the same scenario. CFF consists of five arrays of targets and three firing positions. The kneeling unsupported position with a barricade for concealment is used for the first array of targets. The barricade supported position is used for the next two arrays. The prone unsupported position with a barricade for concealment is used for the last two arrays. The arrays are sequenced to represent an assaulting force with the closest targets first and the farthest targets last.

Array A1.	Kneeling Unsupported	50 to 150 m
Array A2.	Barricade Supported	50 to 100 m
Array A3.	Barricade Supported	100 to 200 m
Array A4.	Prone Unsupported	100 to 250 m
Array A5	Prone Unsupported	150 to 300 m

At the start of each array, all targets appear (pop-up) at the same time, but their exposure time varies with the distance from the firer. Thus within an array, the closer targets drop sooner than the farther targets. Each Soldier decides on the sequence of fire to use for each array.

In addition to target arrays, Soldiers must hit some targets more than once to have what was called a "kill." The starbursts in Figure 7 indicate how many hits are required on each target. If a target requires multiple hits, it pops up again after being hit, with the total time for each target (regardless of hits required) in each array as shown in Figure 7 and Table 10. There are 15 target exposures, but 26 total hits are possible.

Soldiers have three magazines, each containing 10 live rounds plus one dummy round. Thus, Soldiers have four more rounds of live ammunition (a total of 30 rounds) than the total number of required target hits (26 hits). When Soldiers miss a target, they can make the decision to fire at it again, assuming it is still exposed and ammunition is available, or they can fire at another target. Therefore, Soldiers control which targets they engage, when they engage them, and which targets to re-engage after a miss. Because Soldiers control their own sequence of fire and how many rounds fired at an array, they also must change their magazines on their own.

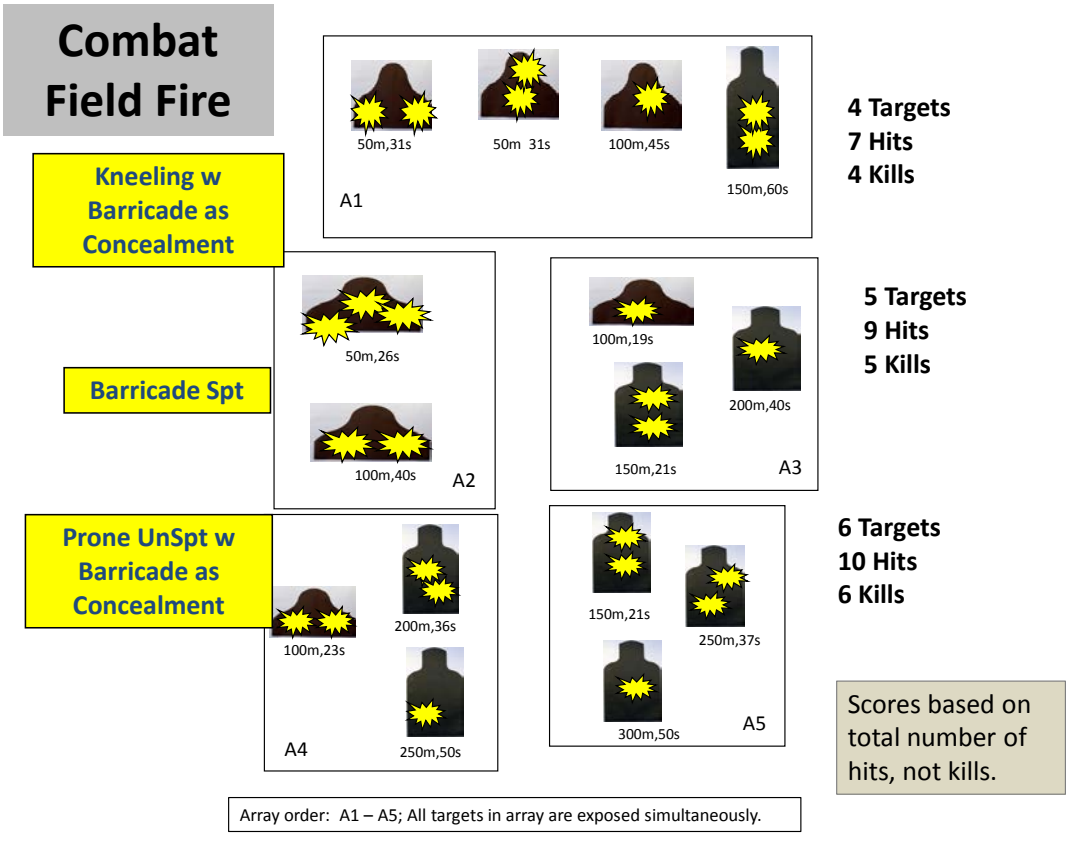

Figure 7. Combat Field Fire. (Starburst graphics on each target indicate the number of hits required for what was called a "kill.")

Two other features of CFF require skill in weapons handling. One is reacting to a simulated malfunction when encountering the dummy round. The dummy round is randomly inserted in each magazine, but cannot be the first or the last round. The Soldier must correct the simulated malfunction behind the barricade, and then reacquire targets in the array. The second skill is that Soldiers must change magazines on their own, as needed, when engaging targets. This is in contrast to many courses-of-fire where magazine changes are all controlled from the range tower.

The major differences from the qualification course (FM 3-22.9, DA, 2011) are:

- All firing positions involve a barricade.
- Soldiers must hit some targets more than once, and Soldiers must constantly scan to determine which targets remain to be engaged.
- Soldiers have more rounds than required target hits.
- Soldiers are presented with arrays where the target exposure time depends on distance to the target.
- Soldiers control which targets they engage and when they engage them.
- Changing magazines is under the Soldier's control.
- Soldiers must correct simulated malfunctions.

Table 10

CFF Course-of-Fire

Target Distance (meters)	Target Exposure Time (sec in array)	# Hits Required
Array A1 Kneeling supported		
50 – L (F-silhouette)	31	2
50 – R (F-silhouette)	31	2
100 (F-silhouette)	45	1
150 (E-silhouette)	60	2
Array A2 Barricade Supported, Phase I		
50- L or R (F-silhouette)	26	3
100 (F-silhouette)	40	2
Array A3 Barricade Supported, Phase II		
100 (F-silhouette)	19	1
150 (E-silhouette)	21	2
200 (E-silhouette)	40	1
Array A4, Prone Unsupported, Phase I		
100 (F-silhouette)	23	2
200 (E-silhouette)	36	2
250 (E-silhouette)	50	1
Array A5, Prone Unsupported, Phase II		
150 (E-silhouette)	21	2
250 (E-silhouette)	37	
300 (E-silhouette)	50	1
Total Hits		26
Total Kills (1 kill / target)		15

Note. All targets in an array come up at the same time, but exposure time varies with target distance.

Method

Soldiers

The initial effort involved Soldiers from ten Initial Entry Training (IET) companies: six Infantry OSUT Companies and four Basic Training Companies (BCT) at Ft. Benning. All Soldiers were male. Company sizes ranged from 152 to 235, for a total of 1,820 Soldiers.

Dummy Round Procedure

A standing operating procedure for loading the dummy rounds was created. The intent of the CFF scenario was to have dummy rounds occur at random for each Soldier, and to be equally distributed across all magazines, between the second and the tenth live-round. During pilot work, it was determined that, without guidance, Soldiers in the ammunition detail typically loaded the dummy rounds as the fifth, sixth, or seventh round. They did not distribute the rounds randomly in the magazines. Consequently, a procedure was developed for the ammunition detail to ensure that rounds were equally likely to occur as the second through the tenth round (could not be first or last round, per the CFF scenario). This procedure is presented in Appendix C.

The dummy round procedure assumed a nine-man detail. Each individual put a dummy round in a unique location. This reduced confusion among the individuals in the detail, as each individual had a specific responsibility. This also ensured that rounds were equally distributed in the second through the tenth positions.

The last step was to "mix-up" all magazines prior to distributing them to the firers. It was important to mix-up the magazines, as the typical procedure used by the ammunition detail is to systematically stack the magazines from one individual in the detail and then add the magazines from the next individual, etc. Although this did not guarantee a "random" distribution, it did substantially reduce the likelihood that Soldiers had the dummy round in the same location in all three magazines. On occasion, Soldiers had magazines with dummy rounds in the same location. However, during the interviews Soldiers indicated that they were not aware of this when they fired CFF.

Changing Positions

In accordance with protocols for range firing, commands from the tower to the Soldiers on changing firing positions were established. They were brief, consistent with the intent to approximate a combat fire situation. These commands were: "Assume a good kneeling position," "Assume a good barricade position," and "Assume a good prone position."

Data Collection Procedures

Special data collection techniques were developed to document Soldiers' performance. It was important to document whether a Soldier missed a target or failed to fire at it, as the score sheet from the range tower did not provide this information. Soldier shooting patterns on each lane were documented by 16 trained observers (other Soldiers) from each participating company.

A lane observation sheet was developed that required observers to record which round in the magazine was fired at which target, when simulated malfunctions (dummy rounds, coded as DR) occurred, when a Soldier changed magazines, and when no ammunition was available. All rounds in each magazine were numbered 1 through 11, including the dummy round. Observers did not record whether the Soldier hit the target. After the observation forms were completed, the number of hits achieved were obtained from the range tower record and added to the forms as well as the number of hits required for a kill. An example of a complete observation sheet is in Table 11. An observer was assigned to each firing lane, so every Soldier was observed.

Table 11

Example of CFF Lane Observation Sheet for one Soldier Augmented with Hits Achieved and Required

		Observation Sheet		
# Hits Achieved	# Hits Required for a Kill	**Target Distance**	**Round # used to engage each target (#s 1-11 for each magazine) *"Mag Chg" when changed magazines.***	**Round # where a malfunction occurred**
			Kneeling	
2	2	**50m L**	***2; 4***	***6 DR***
2	2	**50m R**	***1; 5***	
1	1	**100m**	***3***	
2	2	**150m**	***7; 8; 9; 10; 11; Mag Chg***	
			Barricade	
2	3	**50m L/R**	***1; 4***	***6 DR***
2	2	**100m**	***2; 3; 5***	
		[Pause in Scenario]		
1	1	**100m**	***7***	
2	2	**150m**	***8; 9***	
1	1	**200m**	***10***	
			Prone	
2	2	**100m**	***11; Mag Chg; 1***	***9 DR***
2	2	**200m**	***6; 7***	
0	1	**250m**	***2; 3; 4; 5; 8; 10***	
		[Pause in Scenario]		
1	2	**150m**	***11***	
0	2	**250m**		
0	1	**300m**		
20	26		**Rounds remaining? No**	

Table 11 illustrates that the Soldier achieved all the required hits in the first firing array, but took three rounds more than required to hit the 150 m target twice. The dummy round (DR) was the sixth round, and the Soldier changed magazines at the end of this array as the last round (#11) was fired at the 150 m target. Progressing to the next array, you find that the Soldier did not hit the 50 m target the required three times, but did hit the 100 m target twice, although three rounds were used to achieve the two hits. Skipping to the fourth array, you find that the Soldier changed magazines when engaging the first target, and was unable to hit the 250 m target despite repeated attempts. The dummy round was the ninth round in the magazine. On the last array, the Soldier only had one round of ammunition remaining, which was fired at the 150 m target and was a hit. So for the last array, no rounds were fired at the 250 m and 300 m targets. You can also tell from the sequence of fire (the round numbers) for each array that this Soldier tended to fire at the closest targets first. The total score (see first column - # hits achieved) was 20 hits out of 26 required.

These data were then coded for analysis. Results for each target for each Soldier were coded as a string variable which incorporated six dimensions:

-Number of hits
-Number of misses
-Number of no fires (Soldier with "no fires" fired fewer rounds than required)
-Presence of an induced malfunction
-Magazine change executed
-Whether ammunition was not available

Soldiers fired a practice iteration of CFF, replicating what was done with the qualification course. Soldiers' scores on the current qualification course were also obtained. A sample of approximately15 Soldiers from each company was interviewed after completing CFF to obtain their reactions to CFF.

Findings: CFF Standards and Soldier Shooting Patterns

Establishing CFF Standards

The procedure used to establish CFF standards assumed that leaders were satisfied with the percentage of Soldiers which typically achieve Expert, Sharpshooter, Marksman, and Unqualified status on their first attempt at qualification (after a practice record fire attempt). The qualification course (also known as record fire [RF]) which existed at the time the CFF research was done is documented in Table A3, Appendix A. Similarly, Soldiers had a practice iteration for CFF and a second one "for record." The percentages of Soldiers who fell in each marksmanship category for qualification (i.e., record fire [RF]) were calculated for each company. This percentage template was then applied to determine the number of CFF hits for CFF marksmanship categories for the same company. When an exact match in percentages was not possible, the closest approximation was used. For example, if a company had 10% Experts, 25% Sharpshooters, 40% Marksman, and 25% Unqualified, CFF cut-points were established for each of these categories that matched the same percentages for each category. But because the

range of RF scores is larger (0 to 40 hits) than the CFF scores (0 to 26 hits), exact matches could not always be made.

This template-matching procedure was iterated 12 times. It was done for each of the 10 companies, using the unique distribution of Soldiers on RF for each company. The result of this process was a set of CFF cut-points specific to each company. Then all Soldiers were pooled and the same process was applied to the pooled sample. Cut-points from the pooled sample were used as the recommended divisions between marksmanship categories. The last step was to determine whether the cut-points were replicated with Drill Sergeants from each company (total of 29). The pooled result was validated by the Drill Sergeant sample. However, the result was not validated with a sample of Drill Sergeant candidates (n = 86) due to low scores.

This procedure yielded consistent results despite variations in company expertise. Other techniques such as cluster analysis and establishing cut-points for each firing array within CFF were tried. However, they did not produce distinct clusters or scores consistent with total hits.

Figure 8 shows the frequency distributions of the pooled RF or qualification scores and the pooled CFF scores (# hits) and the correspondence between RF and CFF. CFF cut-points were:

Expert:	24-26
Sharpshooter	21-23
Marksman	16-20
Unqualified	< 16

As shown in Figure 8, the percentages in the CFF categories closely approximated RF for the top three marksmanship categories; the percentages for those classified as unqualified were the same. The frequency distributions are in tabular form for both RF and CFF in Tables C-1 and C-2 in Appendix C.

The cut-points established for each of the 10 companies for Expert, Sharpshooter, and Marksman are shown in Table C3, Appendix C. Also shown is the final recommendation, and the cut-points which emerged when the Drill Sergeants were tested. For each of the marksmanship categories, the companies varied by plus or minus one hit from the final recommendation.

To meet potential Army applications of CFF, two other standards were established based on number of hits: TPU (trained, needs practice, not trained) and Go/No Go. Table 12 documents the cut-points for all standards.

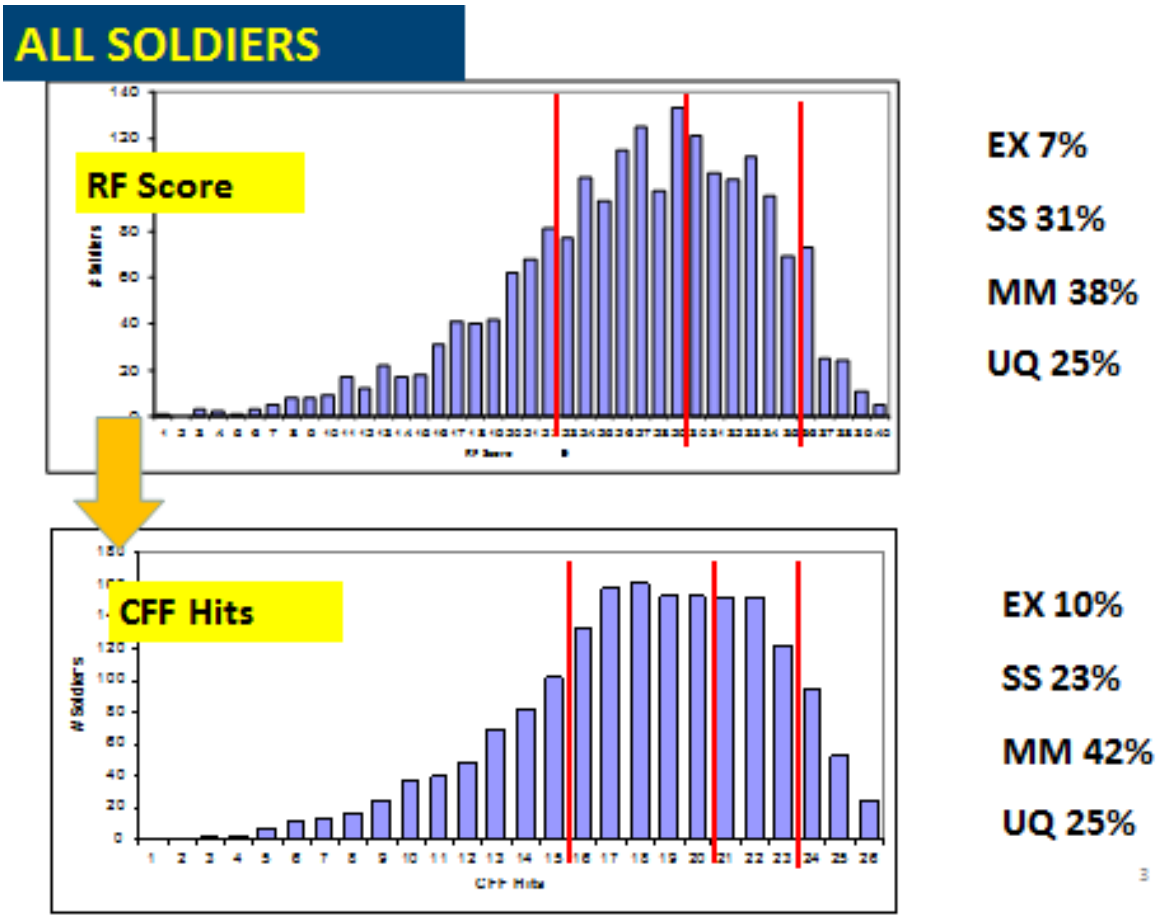

Figure 8. Correspondence between marksmanship category percentages for RF and CFF.

Table 12
Recommended CFF Cut-Points for Different Standards

CFF Hits	CFF Category	TPU	Go / No Go
24-26	Expert	Trained	Go
21-23	Sharpshooter	Needs Practice	Go
16-20	Marksman	Needs Practice	Go
<16	Unqualified	Not Trained	No Go

Another scoring procedure (called points) was examined at the request of the brigade commanders. This score incorporated an additional weight for kills but was eliminated because it required hand-computing, gave too much weight to a kill, and did not appear to provide additional motivation for Soldiers as was initially assumed. Lastly, kills were not considered as the basis for standards due to the restricted range of possible scores for kills (0-15) which hindered the ability to distinguish Soldiers with differing levels of proficiency.

RF and CFF Scores

Summaries of the RF and CFF scores are in Table 13. Both RF and CFF scores increased from practice firing to record firing. Shifts in the percentage of Soldiers in the marksmanship categories also changed, with the greatest shift being a reduction of Soldiers classified as unqualified (Table 13). Thus Soldiers learned from the practice firing on both scenarios.

Table 13
Descriptive Statistics on Hits for the RF and CFF Courses for All Soldiers

	RF Scores		**CFF Scores**	
	Practice	For Record	Practice	For Record
N	1920	1976	1884	1820
Mean	24.60	26.66	16.56	18.05
SD	7.12	6.70	5.07	4.47
% Expert	4%	7%	6%	10%
% Sharpshooter	24%	31%	17%	23%
% Marksman	37%	37%	39%	42%
% Unqualified	35%	25%	38%	25%

Correlations between the two courses-of-fire are in Table 14. Correlations between RF and CFF were lower than the correlations between the practice and final record scores for each course-of-fire (Table 14, all were significant). The correlations between the practice and record fire for each course were moderate, probably because Soldiers were still gaining marksmanship skills. The lower correlations between the two courses-of-fire provide indirect evidence that the two courses are not measuring identical marksmanship skills, yet there are commonalities.

Table 14
Correlations Between RF and CFF Course Scores

	RF: Practice	RF: For Record	CFF: Practice	CFF: For Record
RF: Practice	1.00	.56	.44	.44
RF: For Record		1.00	.42	.46
CFF: Practice			1.00	.55
CFF: For Record				1.00

Soldier Performance on CFF

The individual lane data were analyzed to better identify shooting patterns on CFF. Common to all Soldiers were the five initial target array presentations. Beyond that point, the target presentation depended on what target was engaged, the outcome of that engagement, and the Soldier's decision on which target to engage next, assuming ammunition was available. Consequently, the exact scenario that each individual experienced reflected the consequences of his/her actions and decisions.

Two examples of lane observation and hit data are presented in Table 15 to illustrate differences in Soldier performance. The hits were from the automated scoring procedure for the

range; the observer did not score hits. Soldier A was classified as Expert with 24 hits out of 26 possible, and Soldier B was classified as Unqualified with 15 hits. Results for the first two arrays are shown for each Soldier. As documented in Table 15, the shooting strategies of these two Soldiers differed as well as their ability to hit targets. In the first array, Soldier A engaged both of the 50 m targets first with the first four rounds; then progressed to the 100 m and 150 m targets. On the other hand, Soldier B, used the first four rounds to fire one round at each of the four targets (50 m to 150 m). For Soldier A, the fifth round was a dummy round. Soldier B did not have a dummy round during the first array. Both had two rounds remaining at the end of the first array. On the second array, both Soldiers had to change magazines, but Soldier B also had a dummy round and it was the first round in the magazine for that array (round #10). Soldier A hit each target the maximum number of times, but Soldier B did not. At the end of the second array, Soldier A had eight rounds in the second magazine; Soldier B had six rounds in the second magazine.

At the end of the second array, differences in the ammunition available for the two Soldiers emerged. Soldier A had 19 rounds (including the dummy round) remaining in both magazines; Soldier B had 17 rounds (including the dummy round) remaining in both magazines. A total of 14 hits was required in the last three target arrays. Not shown in Table 15, but of additional interest, is that Soldier A had two live rounds remaining at the end of CFF and hit all targets in the last array. In contrast, Soldier B had no ammunition for the last array.

Table 15

Examples of Lane Observation Data and Hits Achieved in the First Two CFF Arrays for Two Soldiers

Hits Achieved (kill or no kill) / Hits Required for Kill	Target Distance	Round # and Mag Chg	Dummy Round #	Description of Performance
Soldier A with 24 total hits				
Kneeling Position: Array A1				
2 (kill) / 2 req'd 2 (kill) / 2 req'd 1 (kill) / 1 req'd 2 (kill) / 2 req'd	50m L 50m R 100m 150m	1; 3 2; 4 6 7; 8; 9	5	Engaged closest targets with first 4 rds. Had only one miss - the 150m target Dummy round was 5th round.
Barricade Position: Array A2				
3 (kill) / 3 req'd 2 (kill) / 2 req'd	50m L/R 100m	10; 1; 3 11; Mag Chg; 2		No misses. Magazine change after engaging the 100m target
Soldier B with 15 total hits				
Kneeling Position: Array A1				
2 (kill) / 2 req'd 2 (kill) / 2 req'd 1 (kill) / 1 req'd 2 (kill) / 2 req'd	50m L 50m R 100m 150m	1; 7 2; 5 3 4; 6; 8; 9		Did not systematically engage closest targets first Had 2 misses at the 150m target No dummy round
Barricade Position: Array A2				
2 (no kill) / 3 req'd 1 (no kill) / 2 req'd	50m L/R 100m	11; Mag Chg; 1 2; 3; 4; 5	10	Magazine change & dummy round with 50m target Did not fire a third round at 50m; 3 misses at the the 100m target

To provide an overall picture of the performance differences between Soldiers classified as Expert, Sharpshooter, Marksman, and Unqualified on CFF, the probability of a "kill" (defined as achieving the required number of hits) for each target was examined. These results are shown in Figure 9. The targets are ordered by the sequence of arrays cited previously in Table 10 on the CFF course and from the closest to the farthest within each array. The probability of "kill" is graphed for each CFF marksmanship category. The probabilities of "kill" shown in Figure 9 are cited in Appendix C, Table C4.

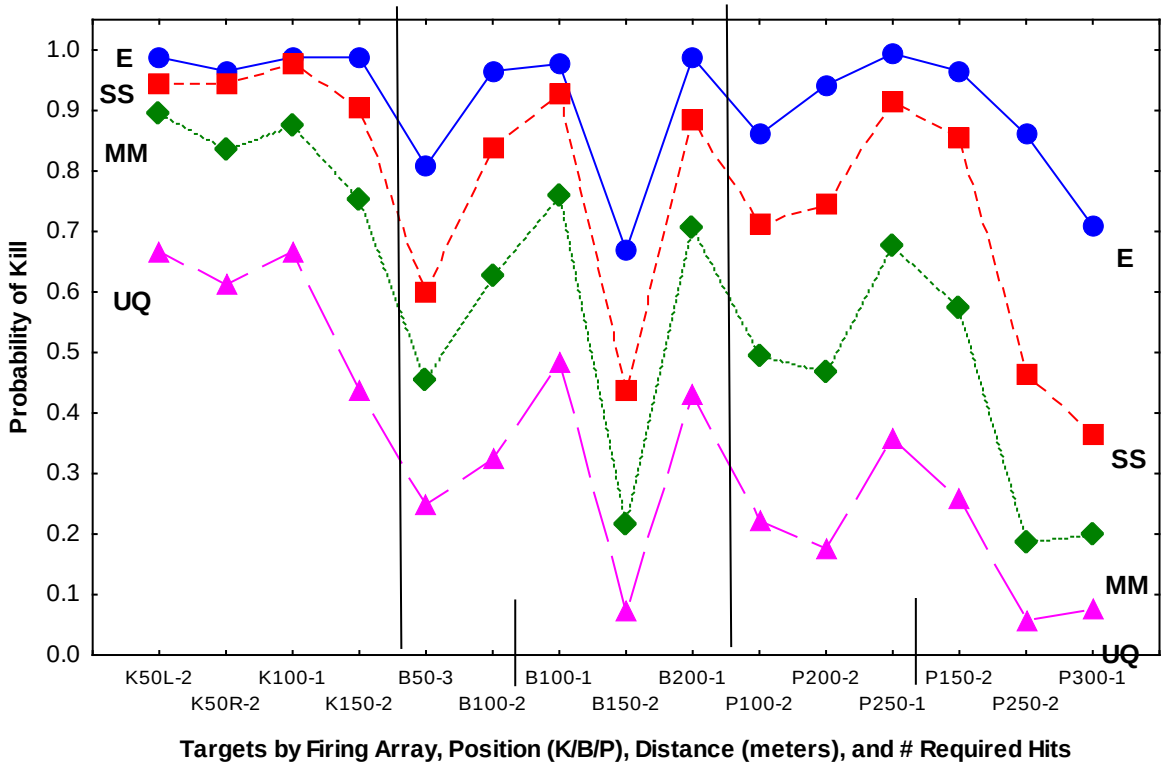

Figure 9. Probability of "kill" by CFF marksmanship category: Initial research

There were consistent differences in performance on each target with Experts highest, followed by Sharpshooters, then Marksmen, and then the Soldiers classified as Unqualified (see Figure 9). However, there was a shift in the relative magnitude of these differences from the start to the end of CFF. Of interest is that Soldiers in the Unqualified category were already performing at a lower level in the first array, kneeling position, than Soldiers in the other three categories. However, for the last two targets in the last array, the Experts' performance was higher and distinct from Soldiers in the other three categories, reflecting the cumulative impact of the scenario on Soldiers in those categories.

There were two major "dips" in the probability of "kill" for all Soldiers – the 50 m target in the barricade position which required three hits (Array A2, see Figure 7 and Table 10), and the 150 m target in the barricade position which required two hits (Array A3). Further examination of the lane observation data indicates different causes for these two "dips." In the first case for the 50 m target, which was in the first array when firing from the barricade, Soldiers had to change magazines, which provided a distraction, and both targets (50 m and 100 m) required multiple hits. Misses occurred most frequently with the 50 m target. However, failures to fire, called "no fires," were also common on the 50 m target as its total exposure time had expired before many Soldiers could fire the required three rounds. In the second case, the 150 m target (in Array 3, a three-target array, barricade supported) was the only target which required multiple (2) hits and its total exposure time was only two seconds longer than the 100 m target in the array. Most of the failures to get a "kill" on this target were due to "no fires," because of the short exposure time. Some Soldiers indicated they never saw the target pop up again; others said they saw it but did not have time to engage it.

In the last position, prone unsupported, magazine changes had a negative impact on Soldiers in the Marksman and Unqualified categories on the first 100 m target (Array A4). However, for the last targets from this position (Array A5), a major impact on the likelihood of hitting and killing a target was whether the Soldier had ammunition. Many Soldiers were out of ammunition in this phase, due to their lack of skill in hitting targets. They missed prior targets several times in their attempts to achieve a hit, and consequently had expended all the additional rounds in their magazines at this point.

The results clearly indicate that the Soldiers' shooting performance was not primarily a function of distance to the target and firing position, which is the case with the qualification course-of-fire. Additional performance measures showed how other factors discriminated the Soldiers in the CFF marksmanship categories. These major performance distinctions are cited next.

Table 16 gives a picture of the shooting accuracy of the Soldiers as a function of the CFF categories. It shows the percentages of Soldiers who achieved a "kill" with only hits and the percentage of Soldiers who achieved a "kill" that involved both hits and misses, without changing magazines or encountering a dummy round. Clearly, Experts were the most accurate, and Unqualified Soldiers the least accurate. These data are based on the very first three targets in Array A1 (two 50 m targets and one 100 m target). The very first three targets were selected as the cumulative effects of the scenario were minimal at this point (e.g., everyone had ammunition).

Table 16
Percentage Soldiers Achieving a "Kill" With Hits Only Versus Hits Plus Misses

CFF Category	% Soldiers with a Kill	
	Hits Only	Hits with Misses
Expert	69%	12%
Sharpshooter	65%	14%
Marksman	64%	17%
Unqualified	52%	23%

Note. Percentages do not sum to 100% for each CFF category, as "kills" with malfunctions and dummy rounds are not included.

"No fires" also discriminated Soldiers in the CFF marksmanship categories. No fires always resulted in a failure to "kill" a target. They were typically associated with limited exposure times, malfunctions, magazine changes, and/or targets requiring multiple hits. The two targets where kills were most affected by "no fires" (versus no kills due to all misses or no ammunition) were the 50 m target in the first barricade array (Array A2) and the 150m target in the second barricade array (Array A3). These targets correspond to the two "dips" in the probability of "kill" graph (Figure 9). "No fires" on the 50 m target ranged from one to three "no fires." "No fires" on the 150 m target ranged from one to two. Any Soldier with three "no fires" on the 50 m target never hit the target; any Soldier with two "no fires" on the 150m target never hit the target. Regardless of pure "no fires" or "no fires" paired with hits, Experts had the fewest "no fires" for these two targets (19% and 22%, respectively). Sharpshooters had more "no fires" (31% and 32%, respectively), Marksmen had even more "no fires" (45% and 40%, respectively). Of the Soldiers classified as Unqualified, 44% to 55% had "no fires"; with two "no fires" the most frequent case for the 150 m target.

Table 17 shows two other factors that impacted performance. When malfunctions and magazine changes occurred, Experts were most likely to "kill" targets, then Sharpshooters, then Marksmen, with Unqualified the least likely.

Table 17
Percentage Soldiers Achieving a "Kill" when Malfunctions and Magazine Changes Occurred

CFF Category	% Soldiers with a Kill	
	Malfunction	Magazine Change
Expert	89%	93%
Sharpshooter	81%	85%
Marksman	60%	65%
Unqualified	41%	47%

Note. Malfunction percentages based on all targets. Magazine change percentages based on the two targets where the most magazine changes occurred.

Lastly, whether the Soldiers had ammunition to engage the last and farthest target, which was at 300m, also varied systematically with proficiency level. Of the Experts, 89% had ammunition for this target. The percentages for the other marksman categories were Sharpshooters, 68%; Marksmen, 53%; and Unqualified, 49%. Thus only half the Soldiers in the Marksman and Unqualified categories had ammunition for the last target in the CFF scenario. This reflects the cumulative negative impact of more refires because of misses in the prior target arrays.

Soldier Interviews

A sample of Soldiers from each company was interviewed after the second (i.e., last) iteration of CFF. A total of 151 Soldiers was interviewed. When the interviews were conducted, the CFF marksmanship categories had not been determined. But we interviewed Soldiers with a

broad range of hits. Compared to all Soldiers, the sample interviewed had a slightly higher percentage of Experts, a lower percentage of Marksmen, but similar percentages of Sharpshooters and Unqualified Soldiers.

In general, Soldiers indicated that the first iteration of CFF helped performance on the second iteration. They became more aware of the target arrays, time of exposure, target location, and number of hits required. They learned they should not rush and should stay calm. The first iteration gave them more confidence. Consistent with the objective measures of Soldier performance, Sharpshooters and Experts did not cite weapon malfunctions as creating a problem, nor did they indicate that they fired repeatedly at a target in order to hit it. Higher-scoring Soldiers also indicated that they engaged the closest targets first; some of the lower-scoring Soldiers indicated that they did not always employ this strategy. Higher-scoring Soldiers did not cite any problems with marksmanship fundamentals. Marksmen and Sharpshooters stated they needed more practice on the kneeling and barricade firing positions. For example, they commented that they tried out different barricade positions to determine which worked best for them.

Only three Soldiers who were interviewed, all Experts, indicated they kept track of the exact number of rounds fired and that they tried to conserve ammunition. Soldiers who indicated they were not aware they would run out of ammunition were those classified as Unqualified. Other Soldiers who ran out of ammunition indicated they were aware this would happen, but typically indicated they kept shooting because they wanted to hit the target.

Soldiers' recommendations were to focus on the fundamentals, such as sight picture, malfunction procedures, and breathing. The recommendation by one Soldier to "keep the same sight picture and be able to do this quickly and instinctively" is particularly relevant to the CFF scenario. Other comments were that not rushing shots and learning to transition between targets contributed to success.

In addition, Soldiers who did well in the first iteration were able to verbalize how they could improve the second time. That was not the case for those who scored poorly. The complexity and multiple demands made by CFF seemed to overwhelm them and they could not describe what they needed to focus on in order to improve their performance on the second iteration.

CFF: In Basic Rifle Marksmanship or Advanced Rifle Marksmanship?

The experiment counterbalanced the sequence of RF and CFF in the marksmanship program of instruction (POI). For half the companies, RF was the last event in basic rifle marksmanship (BRM) in accordance with the current POI, with CFF as the last event in advanced rifle marksmanship (ARM). For the other half of the companies, this sequence was reversed.

When asked about CFF skills, more Soldiers said many of the CFF skills were more difficult to perform when CFF was in BRM than in ARM. These skills were changing magazines, correcting malfunctions, and remembering to scan for targets that could pop-up

again. "In fact, the percentage of Soldiers who found it difficult to change magazines was more than eight-fold higher when CFF was executed in BRM" (Dyer et al., 2010; p. 61). In addition, Soldiers indicated they gained more confidence in CFF when it was in ARM than in BRM, and twice as many Soldiers indicated they were uncertain of their skills when CFF was fired in BRM.

When examining hit performance as a function of whether CFF was in BRM or ARM, the results tended to support CFF in ARM, particularly for Soldiers who fired with iron sights vs the CCO. Considering all the results and the need for skill integration in CFF, the research recommendation was to make CFF the culminating event in ARM.

Follow-on Validation of CFF Cut-Points

In a later marksmanship effort, both Infantry OSUT and BCT companies fired CFF at the conclusion of ARM (Dyer, et al, 2012). However, the Infantry OSUT POI included more preparation for CFF than did the BCT program. In this research, no lane observation data were obtained. Three OSUT companies (n = 598) and three BCT companies participated (n = 548) in BRM for a total of 1146 Soldiers. For ARM, the total was 977 Soldiers (OSUT, n = 544; BCT, n = 433. At that point in time, the standard for CFF used for IET was Go/No Go, where at least 16 hits were required to achieve a Go. Soldiers also fired the standard qualification or RF course in BRM.

Preparation for CFF differed from the initial research effort just described (Dyer et al., 2010) where the standards were established. Infantry OSUT companies had several barrier shoots, whereas BCT companies had only one. OSUT executed CFF twice, whereas BCT executed CFF only once. The reason for these differences was that restrictions were placed on the ammunition available for ARM training in the BCT companies. On the other hand, the training which OSUT companies received was similar to that which occurred for the companies in the initial effort. Table 18 gives the CFF Go/No Go percentages, plus the mean CFF hit score, the mean RF scores, and the percentages of Soldiers in each marksmanship category for both RF (standard qualification) and CFF.

Table 18
Descriptive Statistics on RF and CFF: 2012 Validation Research

	RF Score for Record		CFF Score		
	BCT	OSUT	BCT – For Record	OSUT – Practice	OSUT – For Record
N	548	598	433	544	512
Mean	26.20	27.77	12.67	17.64	18.88
SD	6.24	5.89	5.58	4.05	3.63
CFF % Go >=16 hits	NA	NA	35%	70%	83%
CFF % No Go < 16 hits	NA	NA	65%	30%	17%
% Expert	5%	7%	1%	6%	9%
% Sharpshooter	26%	36%	5%	19%	26%
% Marksman	44%	39%	29%	45%	49%
% Unqualified	25%	18%	65%	30%	17%

Note. There was a significant difference between OSUT and BCT on first attempt at CFF ($F[1,975] = 260.15$, $p < .000$) and between OSUT and BCT on RF ($F[1,1144] = 19.17$, $p < .000$). Maximum score for RF was 40 hits; maximum score for CFF was 26 hits.

The validity of the CFF cut-points could only be re-examined for the Infantry OSUT companies, as the validation required a practice fire and a record fire (two iterations of CFF). As indicated in Table 18, when comparing the OSUT RF percentages to OSUT CFF percentages, the percentages in the CFF Expert and Unqualified categories very closely matched the RF percentages, as was the case in the initial research (Dyer et al., 2010), validating these two cut-points. There was some discrepancy in the cut-point dividing Marksman from Sharpshooter. If the Soldiers who achieved 20 hits (64 Soldiers) had been categorized as Sharpshooter, then the Marksman and Sharpshooter percentages would have been 36% and 37%, respectively, a closer match to the RF percentages. This simply illustrates the difficulty in finding correspondence between scales with different ranges (i.e., 40 hits vs. 26 hits).

These results also indicate that when Soldiers do not receive the necessary practice on the additional skills incorporated in CFF, they do not perform as well (i.e., BCT companies). Although BCT companies scored lower than the OSUT companies on both courses-of-fire, the difference was not substantial on RF, whereas it was substantial on CFF. On RF, there was a 1.5 point difference between OSUT and BCT companies, but there was a 5 point difference on the first iteration of CFF. Also, the percentage of BCT Soldiers who did not qualify on CFF was high (65%) after minimal preparation for the CFF course-of-fire.

For the last CFF firing in the Infantry OSUT companies, the probability of "kill" results, as a function of the targets in each array, were also examined. This allowed another comparison of results with the initial research effort (see Figure 9). Figure 10 shows the results for the follow-on validation effort. In general, the differences between the marksmanship categories paralleled the results in the initial effort. Major consistencies were as follows:

- Experts' probability of kill was consistently high
- Probability of kill dropped in the last target array, with Unqualified firers already at a very low probability of kill
- Probability of kill was highest in the first array, specifically the first three targets (Kneeling). Differences among the marksmanship categories also emerged in the first target array.

- Some inconsistencies with the initial data occurred with the Marksman and Unqualified firers.
  The most obvious discrepancy is with Target B50-3 (see label in Figure 10). This was the 50 m target that required 3 hits for a kill from a barricade position. Specifically, the probability of kill for Soldiers in the Unqualified and Marksman categories were higher than in the initial effort, with Soldiers in both categories at similar levels of performance. However, in the initial effort, the probability of kill dropped for both categories, with the probability of kill for those in the Unqualified category being much lower than those in the Marksman category.

As no observations of the Soldiers were made to tally when they fired at a target, when they ran out of ammunition, when they made their magazine changes, etc., it is not possible to explain or describe the major behaviors as a function of the marksmanship category. However, it seems reasonable to assume that explanation for the "dip" in the third array (labeled B150-2 in Figure 10) was the same as that given in the initial effort, i.e., short exposure time of the target combined with two hits required for a kill. Also, the drop in probability of kill in the last array probably reflects that Soldiers ran out of ammunition, although it appears that the Experts had ammunition for the farthest (300m) target.

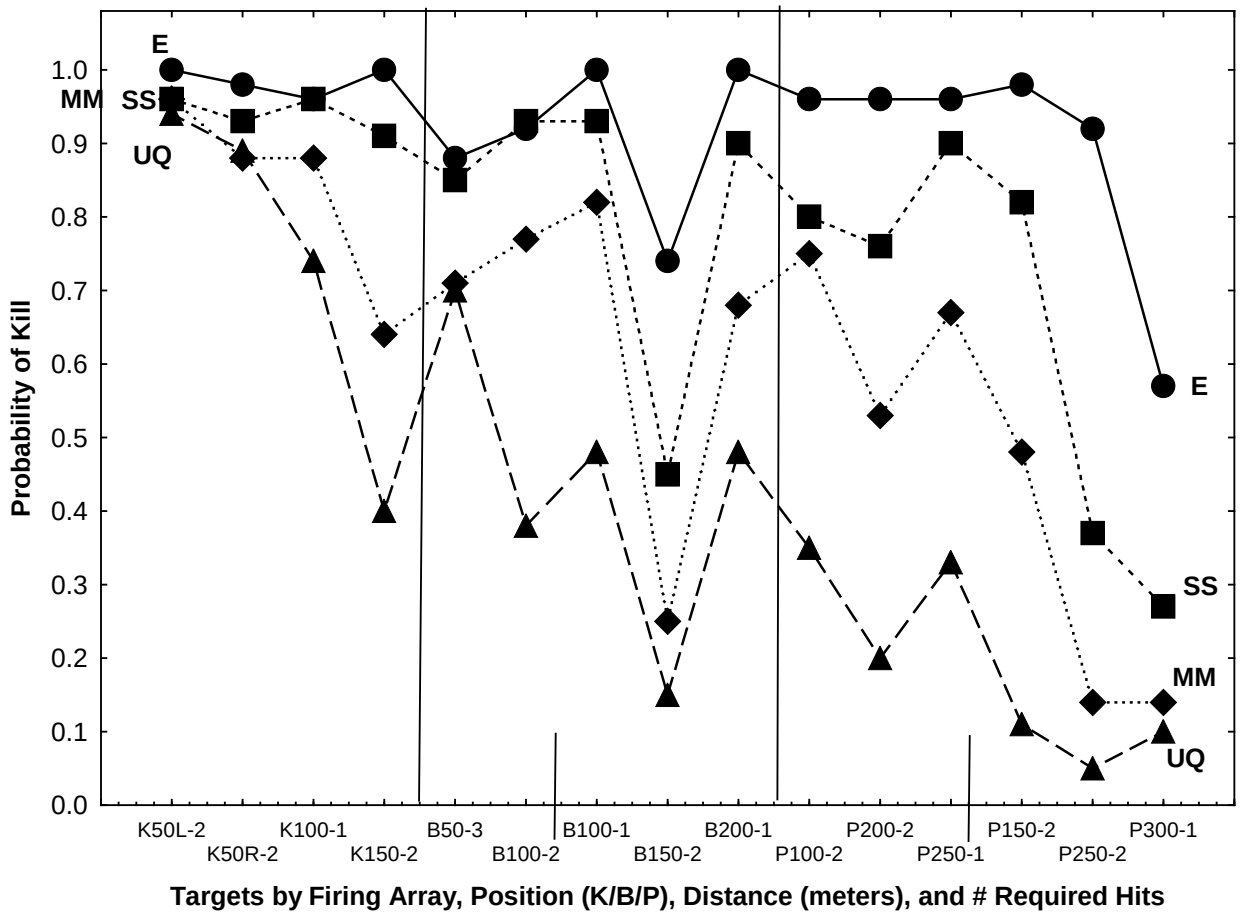

Figure 10. Probability of "kill" by CFF marksmanship category: Validation research.

Of interest is that the discrepancy cited above for the Marksman and Unqualified categories corresponded to when the target arrays changed and matched to some degree when Soldiers could have changed magazines. The higher probability of kill on the next target array could have resulted from Soldiers managing to have a "new" magazine at the start of that array, thus allowing for fewer disruptions to their focus on the array and sufficient ammunition for repeated firings.

CFF Discussion and Conclusions

Skills Required in CFF

Both the performance and interview data showed that CFF was more complex and demanding than the Army's RF (i.e., qualification) course. It was clear that Soldiers had to integrate more marksmanship skills than is the case with RF. Consequently, training for CFF should focus on skill integration. For example, instead of practicing on just the motor skills necessary to change a magazine rapidly, a Soldier should practice changing magazines from a concealed position, followed by assuming a stable firing position and reacquiring a good sight picture. Dry-fire practice from a barricade enabled Soldiers to learn how to establish a good firing position including one that enabled them to scan their entire sector of fire.

Soldiers must make decisions regarding their firing strategy, e.g., which target in the array do they engage first, do they fire another round if they miss the target, do they keep firing if they miss or use rounds for another target. They must also they keep scanning to detect targets which require more than one hit.

However, the complexity of CFF makes it difficult to diagnose Soldier problems or whether Soldiers conduct the weapons handling procedures correctly. With CFF there can be multiple reasons for problems, and the marksmanship weaknesses typically associated with target distance and firing positions do not necessarily apply. Range printouts do not provide the trainer with information regarding when a problem was a failure to scan properly to detect a target, an induced malfunction, a magazine change, or no ammunition available. In addition, some Soldiers shortened the malfunction procedures and only pulled back on the charging handle. Frequently this meant that the cartridge did not eject and the next time the Soldier fired, a "true" weapon jam occurred, which required a Drill Sergeant to remedy the problem. In addition, Soldiers did not always seek concealment when changing magazines. Trainers must closely watch individual Soldiers to detect problems and correct Soldiers so they do not practice procedures incorrectly.

Procedures for Developing Standards

Training Soldiers from each company to be part of the research team (to record each Soldier's actions throughout CFF) was very successful. The information obtained from these records was vital in determining the shooting profiles of Soldiers and in understanding the dynamics of the CFF course-of-fire. We also determined that the lane observation data supported the recommended cut-points. As CFF marksmanship scores declined, there was a progressive degradation in skill on all the behaviors recorded, with Experts the highest, then Sharpshooters, then Marksmen, and lastly Unqualified.

The analytic procedures to determine CFF standards proved to be robust (i.e., using the RF template, applying it to each company, pooling the companies to determine the final cut-points, followed by a validation sample of Drill Sergeants). These procedures yielded similar cut-points despite considerable variations in the percentages of Soldiers in the Expert through Unqualified categories on RF in each company that participated in the initial research (mean RF

scores ranged from 22 to 31). It is important to note that the standards were based on the second iteration of CFF and the scores improved by 12% from the first to the second iteration. Therefore, the same cut-points may not necessarily apply to Soldiers who fire CFF only one time. In addition, with the exception of a small number of Drill Sergeants, it is not known whether the cut-points would change if a large, more experienced marksmanship sample had participated in the research.

"Kills" were not used for CFF standards. One reason was that the number of "kills" was not available on the range printouts for use by leaders and Soldiers. Soldiers in training need immediate feedback on their performance. Second, "kills" are hard to interpret, as they are not a linear transformation of hits. Third, "kills" is a less precise, less sensitive measure of marksmanship proficiency, representing a 15-point scale, whereas hits represent a 26-point scale. Lastly, use of the term "kills" is not consistent with the marksmanship training and doctrine literature.

It is important to stress that the results apply only to the specific CFF scenario investigated, not other variations. This is because of the dependency among the arrays and the resulting cumulative effects of the scenario. Therefore, if the CFF scenario were changed, the standards would have to be re-examined to determine their validity.

Research Method and the Complexity of the CFF Course-of-Fire

The research methods used to obtain information on how Soldiers perform on a new course-of-fire proved successful and provide a model for similar, large scale efforts. Recording the actions of each firer was essential to understanding Soldier performance and explaining the hit results. These data could not have been obtained without expanding the research team with Soldiers as the lane data collectors.

The observations also clarified the major differences between existing courses-of-fire and CFF, which would not have been known otherwise. Unlike RF, CFF is not a scenario where performance primarily reflects firing position and target distance, and where performance on one target is independent of performance on another. The ability to hit targets is a necessary and critical, but not sufficient, condition to do well on CFF. Other factors play a role. For example, to hit targets within an array where targets can appear more than once, forces the Soldier to scan and make decisions regarding the sequence of engaging targets. Soldiers must also decide whether to fire again when missing a target, which in turn impacts success and ammunition available. Weapon handling skills are also important but do not appear to influence results as greatly as ability to hit, scan, and make appropriate engagement decisions. Integration of multiple marksmanship skills is required.

The performance effects of the target arrays are cumulative over the course-of-fire. In contrast with the Army's qualification course, where the outcome for each target is independent of what happens with the next target, misses on CFF have cumulative impacts as often a Soldier fires another round to hit the target. If too many misses occur and Soldiers refire to hit, they can eventually run out of ammunition or decide not to fire, conserving rounds for another target or

array. In either case, the number of hits declines because of marksmanship performance and engagement decisions.

Use of multiple companies allowed verification that the analytic procedure applied to determine the CFF cut-points produced the same cut-points across companies. However, additional validation should include more experienced Soldiers.

The extensive observational data provided insights into Soldier proficiency on CFF and provided decision-makers with a solid foundation for making decisions regarding the potential value and future use of CFF. After the research findings were briefed, the decision by Infantry leaders was to include CFF as the culminating exercise in the IET advanced rifle marksmanship program. In addition, CFF was added as an advanced marksmanship training exercise in the next change to the Army's marksmanship FM (3-22.9, DA, 2011, Change 1). The standards in the FM are the TPU standards, rather than marksmanship categories or Go/No Go.

Clearly, CFF is more complex than the record fire (qualification) course required by the Army when the research was conducted. There are historical precedents in prior qualification courses-of-fire for certain elements of CFF (e.g., more rounds than targets, use of obstacles for firing position) (Dyer et al., 2010). However, none of these courses incorporated all the features in CFF. Lastly, it is easy to overlook the training implications of CFF. If Soldiers are to perform well and meet CFF standards, they must be skilled in marksmanship fundamentals, but trainers must also focus on the additional skills required and enable Soldiers to be proficient in integrating these skills.

Of interest is how findings from a recent survey of combat veterans (Dyer, 2015a, 2015c) supported CFF. Infantry combat veterans, as well as veterans from other branches, stressed the importance of firing from barricades, tactical magazine changes, and the need to fire more than once. Also, Infantry leaders favored requiring a more complex course-of-fire for Infantry, in addition to the standard qualification course. They viewed a more complex course as aligning Infantry shooting requirements with the specialized weapon requirements associated with other branches such as Armor and Field Artillery.

Summary

Two different approaches were used to establish standards for marksmanship courses-of-fire. With night fire, a course-of-fire already existed but was found to be incompatible with the technologies (aiming lights and night vision goggles) used by the Soldier. Thus, the approach was to revise the course and revise the standards. With CFF, a new course-of-fire was developed but no standards existed. The standards that were developed and approved were based on Soldier success in the primary course-of-fire used by the Army. In both cases, the research identified factors that impacted Soldier performance. These factors were also critical in weighing the relative merits of different standards that were considered during the process of making the final recommendations.

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Appendix A

Courses-of-Fire

Table A1 was the course-of-fire used in the initial aiming light research at Ft. Bragg in 1998. It was used for day and night qualification.

Table A1

Record Fire Table in FM 23-9, M16A1 and M16A2 Rifle Marksmanship, Dated 1989

Table 1 Supported Fighting Position				Table 2 Prone Unsupported Position			
Range(m)	Time(sec)	Range(m)	Time(sec)	Range(m)	Time(sec)	Range(m)	Time(sec)
50	3	100		100	5	150	8
200	6	200	8	250	8	300	9
100	4	150	10	150	6	100	
150	5	300		50		200	10
300	8	100	9	200	8	150	
250	7	250		150		250	12
50	3	200	6	200	12	100	
200	6	150	5	50		150	8
150	5	50	6	150	8	200	
250	7	100		100	8	100	9

Table A2 is the current night fire course of fire in the marksmanship FM (FM 3_22.9), that was developed during the night fire research in 1999 and 2000 described in the report.

Table A2

Record Night Fire Tables in FM 3-22.9 Rifle Marksmanship M16-/M14 Series Weapons, Dated 2008 and 2011 (Change 1)

Table 1 Supported Fighting Position				Table 2 Prone Unsupported Position			
Range(m)	Time(sec)	Range(m)	Time(sec)	Range(m)	Time(sec)	Range(m)	Time(sec)
50L	3	100		100	5	150	8
200	6	200	8	200	8	50R	5
100	4	150		150	6	100	
150	5	50R	8	50L		200	12
100	8	100		200	12	150	
150	5	150	8	150		50L	12
50R	3	200	6	100	12	100	
200	6	150	5	50R		150	12
150	5	50L		150	12	200	
250	7	250	9	100	8	100	12

Notes. From DA Form 7489, September 2008 and 2011 (Ch1), Rifle Marksmanship M16-M4 Series Weapons

Expert = 34-40; Sharpshooter = 24-34; Marksman = 17-23; Unqualified = 16 and below.

Table A3 presents the RF/qualification course used in the CFF research.

Table A3

Record Fire Table in FM 3-22.9 Rifle Marksmanship M16A1, M16A2/A3, M16A4 and M4 Carbine, Change 4, Dated 2006, and FM 3-22.9 Rifle Marksmanship M16-/M14 Series Weapons, Dated 2008 and 2011 (Change 1)

Table 1 Prone Supported or Foxhole Supported				Table 2 Prone Unsupported		Table 3 Kneeling	
Range(m)	Time(sec)	Range(m)	Time(sec)	Range(m)	Time(sec)	Range(m)	Time(sec)
50	3	100		200	6	150	8
200	6	200	8	250	8	50	4
100	4	150	10	150	6	100	5
150	5	300		300		150	6
300	8	100	9	200	10	100	5
250	7	250		150		50	4
50	3	200	6	200	12	100	5
200	6	150	5	250		150	6
150	5	50	6	150	9	50	4
250	7	100		150	6	100	5

Note. Based on DA Form 3595-R, July 2006

Appendix B

Probability of Hit Values for the Aiming Light Graphs

Table B1

Probability of Hit Values for Figure 1 (Illumination levels)

	Distance (meters) to Target					
Illumination level	50m	100m	150m	200m	250m	300m
Good	0.93	0.86	0.73	0.17	0.16	0.02
Variable	0.88	0.78	0.52	0.18	0.20	0.13
Poor	0.76	0.60	0.28	0.06	0.00	0.07

Table B2

***Probability of Hit Values for Figure 2 (baseline platoon*)**

	Distance (meters) to Target)					
Sight	50m	100m	150m	200m	250m	300m
CCO-DAY	0.97	0.94	0.86	0.73	0.59	0.43
TWS-NIGHT	0.82	0.78	0.87	0.71	0.60	0.42
AL-NIGHT	0.85	0.74	0.50	0.12	0.10	0.06

Table B3

Probability of Hit Values for Figure 3 (LW platoon)

	Distance (meters) to Target)					
Sight	50m	100m	150m	200m	250m	300m
CCO-DAY	0.98	0.94	0.84	0.59	0.42	0.40
TWS-NIGHT	0.89	0.85	0.76	0.68	0.53	0.46
AL-NIGHT	0.97	0.76	0.48	0.10	0.08	0.00

Table B4

Probability of Hit Values for Figure 4 (OSUT Company)

	Distance (meters) to Target				
OSUT Condition	50m	100m	150m	200m	250m
Practice Qualification	0.54	0.40	0.32	0.17	0.06
Refire	0.58	0.47	0.39	0.15	0.04

Table B5

Probability of Hit Values for Figure 5 (LW platoon –JRTC)

	Distance (meters to Target)					
Sight	50m	100m	150m	200m	250m	300m
CCO-DAY	0.94	0.96	0.92	0.72	0.64	0.49
TWS-NIGHT	0.84	0.87	0.80	0.60	0.50	0.30
AL-NIGHT	0.79	0.67	0.59	0.18	0.02	

Table B6

Probability of Hit Values for Figure 6 (Summary of Research Efforts)

	Distance (meters) to Target					
Soldier Group	50m	100m	150m	200m	250m	300m
Baseline Plt_LW	0.85	0.74	0.50	0.12	0.10	0.06
LW Plt	0.97	0.76	0.78	0.10	0.08	0.00
OSUT Refire	0.58	0.47	0.39	0.15	0.04	NA
LW JRTC	0.79	0.67	0.59	0.18	0.02	NA
Average for the 3 rifle platoons	.87	.72	.62	.13	.07	NA

Table B7

CCO and TWS Probability of Hit Results from Dyer et al. (2005, Reduced exposure firing with the Land Warrior System)

Sight –Day/Night - Firing Position	Known Distance Scenario – Untimed		
	75m	175m	300m
CCO-day - prone	.97	.73	.51
TWS – night- prone	.94	.91	.60
	Field Fire Scenario – Extended Times		
CCO-day - prone	.93	.89	.58
TWS – night- prone	.92	.82	.53
	Field Fire Scenario –Standard Times		
CCO-day - prone	.95	.91	.36
TWS – night- prone	.92	.86	.26

Appendix C

CFF Procedures and Data

Dummy Round Loading Procedure for CFF

Load Each Magazine with 10 live rounds and 1 dummy round
Dummy round CANNOT be the first round or the last round.

	Order of Live Rounds and the Dummy Round										
Mag #	**Rd 1**	**Rd 2**	**Rd 3**	**Rd 4**	**Rd 5**	**Rd 6**	**Rd 7**	**Rd 8**	**Rd 9**	**Rd 10**	**Rd 11**
Mag 1	1	**D**	2	3	4	5	6	7	8	9	10
Mag 2	1	2	**D**	3	4	5	6	7	8	9	10
Mag 3	1	2	3	**D**	4	5	6	7	8	9	10
Mag 4	1	2	3	4	**D**	5	6	7	8	9	10
Mag 5	1	2	3	4	5	**D**	6	7	8	9	10
Mag 6	1	2	3	4	5	6	**D**	7	8	9	10
Mag 7	1	2	3	4	5	6	7	**D**	8	9	10
Mag 8	1	2	3	4	5	6	7	8	**D**	9	10
Mag 9	1	2	3	4	5	6	7	8	9	**D**	10

Mag 1: 1 live round then the dummy round
Mag 2: 2 live rounds then the dummy round
Mag 3: 3 live rounds then the dummy round
Mag 4: 4 live rounds then the dummy round
Mag 5: 5 live rounds then the dummy round
Mag 6: 6 live rounds then the dummy round
Mag 7: 7 live rounds then the dummy round
Mag 8: 8 live rounds then the dummy round
Mag 9: 9 live rounds then the dummy round

Figure C1. Dummy round loading procedures given to the ammunition detail.

Table C1

Frequency Distributions of CFF Hits: Number and Percentage of Soldiers by Number of Hits

CFF Hits	# / % Soldiers
0-1	2 / 0.2
2	1 / 0.1
3	3 / 0.2
4	3 / 0.2
5	8 / 0.4
6	11 / 0.6
7	13 / 0.7
8	17 / 0.9
9	25 / 1.4
10	38 / 2.1
11	40 / 2.2
12	48 / 2.6
13	70 / 3.8
14	82 / 4.5
15	102 / 5.6
16	133 / 7.3
17	158 / 8.7
18	161 / 8.8
19	153 / 8.4
20	152 / 8.4
21	152 / 8.4
22	152 / 8.4
23	122 / 6.7
24	95 / 5.2
25	53 / 2.9
26	25 / 1.4

Note. N = 1820.

Table C2

Frequency Distribution of Record Fire Scores: Number and Percentage of Soldiers by Number of Hits

Score (# Hits)	# / % Soldiers	Score (# Hits) cont'd	# / % Soldiers
1	1 / 0.1	21	68 / 3.4
2	0 / 0.0	22	81 / 4.1
3	3 / 0.2	23	77 / 3.9
4	2 / 0.1	24	103 / 5.2
5	1 / 0.1	25	93 / 4.7
6	3 / 0.2	26	115 / 5.8
7	5 / 0.3	27	125 / 6.3
8	8 / 0.4	28	97 / 4.9
9	8 / 0.4	29	133 / 6.7
10	9 / 0.5	30	121 / 6.1
11	17 / 0.9	31	105 / 5.3
12	12 / 0.6	32	102 / 5.2
13	22 / 1.1	33	112 / 5.7
14	17 / 0.9	34	95 / 4.8
15	18 / 0.9	35	69 / 3.5
16	31 / 1.6	36	73 / 3.7
17	41 / 2.1	37	25 / 1.3
18	40 / 2.0	38	24 / 1.2
19	42 / 2.1	39	11 / 0.6
20	62 / 3.1	40	5 / 0.3

Note. N = 1976.

Table C3

CFF Marksmanship Category Cut-Points: Each Company and Drill Sergeants

CFF Scores	Marksmanship Category	Cut-Points (minimum score for each category		
		Companies	All Soldiers [Recommendation]	Drill Sergeants
CFF Hits	Expert	25, 25, 25 24, 24, 24, 24, 24, 24, 23	24	25
	Sharpshooter	21, 21, 21, 21, 21, 21 20, 20, 19, 19	21	20
	Marksman	17, 17, 17, 16, 16, 16 15, 15, 15,15	16	16

Table C4

Probabilities of "Kill" for the Target Arrays by Marksmanship Category (reference Figure 9)

Target Code	Expert	Sharpshooter	Marksman	Unqualified
Array 1 - Kneeling				
K50L-2	.99	.94	.89	.67
K50R-2	.96	.94	.84	.61
K100-1	.99	.98	.87	.67
K150-2	.99	.90	.75	.44
Array 2 Barricade				
B50 (L or R)-3	.81	.60	.45	.25
B100-2	.96	.84	.63	.32
Array 3 Barricade				
B100-1	.98	.93	.76	.48
B150-2	.67	.44	.22	.07
B200-1	.99	.88	.71	.43
Array 4 Prone				
P100-2	.86	.71	.49	.22
P200-2	.94	.74	.47	.18
P250-1	.99	.91	.67	.36
Array 5 Prone				
P150-2	.96	.86	.57	.26
P250-2	.86	.46	.19	.06
P300-1	.71	.36	.20	.07

Note. Target code: First letter stands for Kneeling (K), Barricade (B) or Prone (P); 50-300 represents the distance to targets (50m targets labeled left and right), last number indicates number of hits required for a "kill."

APPENDIX D

Acronyms

AL	Aiming light
ARI	Army Research Institute for the Behavioral and Social Sciences
ARM	Advanced rifle marksmanship
BCT	Basic Combat Training
BRM	Basic rifle marksmanship
CCO	Close Combat Optic
CFF	Combat Field Fire
FM	Field Manual
GFE	Government furnished equipment
IET	Initial Entry Training
JRTC	Joint Readiness Training Center
KD	Known distance
LW	Land Warrior
NCOIC	Noncommissioned officer in charge
NVG	Night vision goggle
OIF	Operation Iraqi Freedom
OSUT	One Station Unit Training
ph	Probability of hit
POI	Program of instruction
RF	Record fire
TEA	Training effectiveness analysis
TPU	Trained, needs practice, not trained
TWS	Thermal weapon sight
TRADOC	Training and Doctrine Command
TSM-Soldier	TRADOC Systems Manager-Soldier
USAMU	United States Army Marksmanship Unit